THESIS

Thrips Tabaci Lindeman and Aeolothrips Fasciatus Linnaeus with Notes on other Species of Thysanoptera

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1913

THRIPS TABACI LINDEMAN AND AEOLOTHRIPS FASCIATUS LINNAEUS WITH NOTES ON OTHER SPECIES OF THYSANOPTERA

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THRIPS TABACI LINDEMAN.

THE ONION THRIPS.

INTRODUCTION.

At various times the onion thrips has attracted the attention of onion growers and entomologists in New York State. It is undoubtedly present on onions in some localities every year, but it is only occasionally that growers complain about its injuries. In 1910 many complaints were received by the College of Agriculture from onion growers in regard to Thrips tabaci. In seasons when the infestation is heavy the species comes to be of considerable economic importance.

At the beginning of the summer of 1912 a study of the species was begun with the view of obtaining data on its life history in New York and of finding some method of control. At various times the onion fields at Williamson, at Elmira, in Orange County and at Canastota were visited. About ten weeks were spent at Canastota. No control experiments were undertaken because the infestation at Canastota was very slight, due probably to the cool rainy season, and because the serious infestation in the Orange County fields came to my notice when the crop was almost ready to be harvested.

I am indebted to Professor G. W. Herrick for valuable advice and criticism on the work.

HISTORY OF THE ONION THRIPS.

The earliest record I have found of injury to onions by thrips is that of A. S. Packard '72. His attention was called to a serious infestation at Swampscott, Mass. According to Mr. Ware the onions had been injured for the past fifteen years more or less. Dr. Packard estimated that in Essex County alone $10,000 worth of onions were destroyed by thrips the previous season. The injury to the plants was described, and the forms referred to Limothrips tritici Fitch. As Hinds '02 points out, the "description is unidentifiable, but it is sufficient to show that the insect was not Thrips tritici Fitch, nor did it belong to the genus Limothrips." The description does not agree with T. tabaci, but the injury described is so much like that done by this species that Hinds includes the reference under Thrips tabaci. Packard also described and figured a supposed wingless male of Limothrips tritici, which appears to be the larva of Aeolothrips fasciatus Linn., that I have found preying on the onion thrips, and that would therefore naturally be taken with the latter.

A. E. Shipley '87 reported a species of Thrips on onions in Bermuda that appeared to do very little damage.

In 1888 K. Lindeman published the original description of Thrips tabaci and reported it as a serious enemy of tobacco in Russia. His account of the early stages does not agree at all with the results of Quaintance '98 and Hinds '02; this led Hinds to infer that Lindeman had confused

the early stages of very different species. As quoted by Quaintance '98 Lindeman stated that the eggs were glued along the smaller veins of the leaf on the under surface.

Thaxter '90 referred to the "white blast" caused by a new species of Thrips, as the most serious disease to which onions had been subjected in Connecticut in 1889.

Baker's article '91 on a Limothrips species injurious to roses has been referred to by Pergande '95, Quaintance '98, Webster '01 and Hinds '02 under the onion thrips. The figure and description of the species indicate, however, that it was not Thrips tabaci.

Coquillett '92 recorded the onion thrips as injurious to potato and as occurring on tumble weed in California.

Lintner '92 reported injury to cabbage and cauliflower leaves in Pennsylvania by a thrips. Probably he was referring to Thrips tabaci.

Webster '92 reported a Thrips species on onions from Columbus, Ohio.

In 1893 Gillette stated that Thrips striatus ? Osborn had caused much damage to onions and recommended the use of kerosene emulsion as a remedy. Gillette '94 reported the successful use of kerosene emulsion against the thrips.

Sirrine and Lowe '94 reported injury to cabbage and onions by a thrips that was evidently Thrips alii (allii) (Gillette) Beach.

Riley-Howard '94 wrote on "carnation twitters" caused by a true thrips. This note was referred to by Hinds '02

under Thrips tabaci.

Smith '94 reported the abundance of and serious injury by the onion thrips in New Jersey.

In 1895 Osborn and Mally wrote on Thrips tabaci under the name of"the western onion thrips", Thrips alii (allii) Gillette. They gave observations on oviposition, hibernation and the life history in general. Control measures suggested were spraying with kerosene emulsion and clearing up and burning the onion tops after harvest.

Pergande '95 published a complete review of everything that had been written on the species up to that time. In addition he reported that the notes of the Department of Agriculture showed that the species had been received in 1889 and 1891 from Mr. Coquillett from Los Angeles, California, where it had been very injurious to onions. In 1892 Mr. Kline, of Lasalle County, Illinois, had complained of damage done to his onions by this insect. In 1894 F. M. Webster reported that the species was doing serious damage in all onion fields in northern Ohio. In the same year Mr. Kline again reported that the species was abundant and that the thrips went from onions to melons, cucumbers and other plants. The author's own notes showed that he had taken the species in the District of Columbia and in Virginia from February until November, during the period 1882 to 1888 on the leaves of onion, cabbage, cucumber and parsley. He had received it from Germany in 1885 with the report that it was

destructive to the garden leek. Upon comparing the American forms with European specimens of Thrips tabaci Lindeman Mr. Pergande had found the two to be identical. In his opinion the species had been introduced into the United States from Europe. He redescribed the species, stating in regard to the male that "This sex resembles the female in every respect, except that it is much smaller, narrower, and with the end of the body bluntly rounded. Its length is about 0.7 mm."

Uzel '95 described the species Thrips communis male and female and its two varieties annulicornis and pulla, and noted (page 458, 460) that his species was very close to the Thrips tabaci Lind. of Pergande '95 except for a few small differences. Lindeman's description of Thrips tabaci was quoted by him.

In 1895 Webster reported injury to onions by Limothrips tritici Packard (determined by L. O. Howard) in Ohio and published a figure of an injured plant.

Lintner '96 published a bibliography of the onion thrips and a list of food plants. He figured the female with details of various parts and gave an abstract of Lindeman's notes on the life history.

Slingerland '96 and '97 mentioned serious injury by the species in widely separated localities in New York and recommended kerosene emulsion and whale oil soap as remedies.

In 1897 Sirrine reported damage done by Thrips tabaci Lind. to cauliflower and cabbage seed beds and stated that it was a serious pest of onions on Long Island.

In 1898 appeared Quaintance's work on the life history of Thrips tabaci in Florida. Injury to onions, cauliflower and cabbage was reported, fluctuating in seriousness from year to year. The thrips was said to "chafe off the epidermis from the green leaves, thereby causing them to dry out." It occurred on cabbages adjacent to tobacco fields, but it had not attacked the tobacco. Quaintance quoted Lindeman's observations on the life history of the species. The results that he obtained in Florida, however, differed in many respects from those of Lindeman. In Florida he found the length of the stages to be as follows: egg stage 3½ to 4 days; larval stage 7 to 9 days; larval molt 2 to 3 days from birth; nymph (= pupal) stage 4 days; total life cycle approximately 16 days. The length of life of the adult was not satisfactorily determined. Quaintance described the egg, larva (two stages), nymph (only one stage) and the adult female. He quoted Lindeman's description of the male. The antenna of the second stage larva was found by Quaintance to consist of only four segments, whereas Lindeman had considered it as six segmented.

The remedies suggested by Quaintance were whale oil soap (1 lb. to 4 gals. water) or "Rose Leaf Insecticide" (1 pt. to 4 gals. water). Quaintance copied the bibliography given by Lintner '95, adding the reference Targioni-Tozzetti '91. He found that both adults and larvae of Triphleps insidiosus preyed upon Thrips tritici and Thrips tabaci, and that the larvae of a Chrysopa species preyed upon thrips larvae. Occasionally he had pressed a

nematode worm from the abdomen of a thrips, but it was by no means sure that the worm was parasitic.

Pettit '99 reported Thrips tabaci as injurious in Michigan and published figures of the adult and larva; he found a gregarinid parasite in the bodies of dead black thrips larvae.

Quaintance '98 again reported serious injury by Thrips tabaci to onion and cabbage seedlings in Florida.

Webster and Mally '99 mentioned serious injury to onions by thrips in Ohio; the abundance of the pest seemed to depend upon the lack of precipitation during July and early August.

Fernald-Hinds '00 recommended "Nikoteen" for fumigating for thrips (Thrips tabaci) in greenhouses.

In 1901 Fuller reported injury to onions by a species of thrips, probably Thrips tabaci, in Natal, South Africa.

Garman '01 mentioned Thrips tabaci as a pest of greenhouse cucumbers in Kentucky.

In 1901 Webster wrote on "white blast" on onions caused by Thrips tabaci Lind. He reported observations on the hibernation of the species and quoted the life history notes of Lindeman '88 and Quaintance '98. He recommended cleaning up of fields, ditch banks and the cultivation of adjacent land. Experiments in spraying with whale oil soap were reported, a mixture of 1 lb. to 8 gals. water having yielded good results. Frequent drenching rains in June, July and August were said to be an important natural check. Megilla

maculata and maggots of an undetermined syrphid were enemies of thrips, especially of the larvae. A "history of the onion thrips in America" was given, with details of most of the above references. He had found it at Burlington, southern Canada in 1901.

Hinds '02 redescribed the female of Thrips tabaci Lind., giving the synonymy of the species. He stated (page 81) that Dr. Uzel had positively identified Thrips tabaci with his Thrips communis. He quoted Uzel's description of the male of Thrips communis and Quaintance's descriptions of the immature stages. He found, in a cucumber house in January and February, that the egg stage varied from 4 to 7 days and that pupation took place in 7 or 8 days and lasted nearly a week, making the total life cycle about 16 days. He said that "it must be considered, perhaps, the most injurious species of the order."

From Pennsylvania Thrips tabaci was reported as injurious to onions and cabbage by Surface in 1902.

Britton '04 reported serious injury to onions by the species in Connecticut in 1903.

Whetzel '04 had noted onion thrips at various places in New York, especially at East Bethany in 1903.

Buffa '06 listed Thrips tabaci as previously recorded from Italy and Thrips communis, in his collection, as new to Italy.

In 1906 Froggatt reported injury done by the onion thrips in Australia.

From Massachusetts injury was again reported as having occurred in the Connecticut River Valley in 1906 by Fernald and Summers '08.

Crane and Forbes '08 wrote that the onion thrips was the most serious pest of onions in the Southwest and that it had been very abundant at Yuma in 1908.

Beattie '09 mentioned the onion thrips as a very destructive onion pest in the South, especially in the Texas Bermuda-onion section.

In 1909 Smith reported that the drought and thrips together had reduced the crop 1/3 in some onion fields in New Jersey in 1908.

Bagnall had reported Thrips tabaci (= communis Uzel) from England in 1908 and said in 1909 that it was widely distributed, had a wide range of food plants, and was one of the most injurious species of thrips.

Russell '13 reported that Thripoctenus russelli Crawf., a small hymenopterous parasite had been bred from prepupae of Thrips tabaci.

DESCRIPTION.

Egg. The egg is more or less irregularly bean-shaped, about twice as long as wide, and about as thick as wide. The end that projects slightly above the leaf surface is narrower than the other. It is translucent white, without markings. Slightly before the emergence of the larva the bright red eyes can be plainly seen. The length varies from .237 mm. to .291 mm.; the width from .127 mm. to .155 mm., and the thickness from .137 mm. to .146 mm. The average measurements of nine eggs were: length .262 mm., width .143 mm., and thickness (only two measured) .141 mm.

Larva. First stage. (Before beginning to feed.) Measurements: length (average of two specimens) .514 mm., width (of thorax) .142 mm., length of antennae .014 mm., length of head .096 mm. General body color translucent white, eyes conspicuous, bright red in color. Head, antennae, thorax and legs large as compared with abdomen.

Head with four spines, two between the eyes and one in front of each eye. Antenna four segmented, about twice as long as head, two about 1/3 as long as one, three about twice as long as one, four twice as long as three. Segments three and four widest, wider than one and two. One and two sub-cylindrical, three somewhat rounded, and constricted at tip, four slightly thickened at base, tapering rather abruptly from one third its length from tip to tip, annulated. Slight indications of separation of distal one-third as a

fifth segment. One with a spine on the inside, two with three dorsally, three with four, and four with three at tip and many small spines, of which two near the tip are larger. Prothorax with two transverse rows of four spines, one at middle and another at posterior margin. Mesothorax with a single transverse row of four spines.

Abdomen tapering, segments 1 to 8 about equal in length, 9 and 10 equal and longer than preceding ones. Each segment bears a transverse row of five spines dorsally; these increase in length very gradually to the eighth; 9 with four spines posteriorly twice the length of those on segments 1 to 8, 10 with three long slender spines ~~positively~~ posteriorly on each side.

Legs rather short and stout, femur with two or three scattered spines, tibia with a circle of spines about one third of its length from the tip, and with two spines at the tip.

Larva. Second Stage. (Full grown, almost ready to pupate.) Measurements: Total body length 1.08 mm.

	Length, mm.		Width, mm.	
Head	.09		.09	
Antenna	.18		...	
Prothorax	.12	anteriorly	.105	posteriorly .18
Mesothorax	.15	anteriorly	.225	posteriorly .265
Metathorax	.12		.275	
Abdomen	.60	1: .255; 4: .27;	8: .18;	9: .09; 10: .06

General color of body translucent whitish-yellow, to light lemon-yellow in some individuals. Head, antennae, legs and

last two segments of abdomen somewhat lighter. Eyes red. After feeding, alimentary canal can be plainly seen on account of its greenish contents. Body surface with very fine transverse striae, especially on the abdomen where there are five or six striae on each segment.

Head as long as wide, anterior angles rounded, somewhat narrower behind the eyes. Ocelli absent. Four spines on dorsum behind eyes, and two on each side of head. Antenna twice as long as head, translucent white in color, six segmented, the fifth and sixth segments being small, cut off from the narrow tip of the fourth. One and two about equal in length, three and four equal, three times as long as two. Three with a short, narrow pedicel, and somewhat narrower at tip. Four imperfectly spindle-shaped. Six longer and somewhat narrower than five. Three and four widest, almost 1½ times as wide as length of one. One spine on one, three on two, two at tip of three, one at tip of four, and three at tip of six. Third and fourth segments annulated, fourth bearing minute setae on the annulations.

Prothorax 1 1/3 times as long as head, ~~wider~~ narrower in front than behind, with a notch above the fore coxae on each side. Two spines near center, one-third from anterior margin, and three on each side near posterior margin.

Mesothorax about 1¼ times as long as prothorax and 1 7/10 times as wide as long, with two transverse rows of six spines.

Metathorax slightly shorter and wider than mesothorax, forming a rectangular area with the latter. There is an

irregular transverse row of eight spines at middle, and a row of four spines near the posterior end.

Legs translucent white, moderately stout. Femur with two spines on outside, and a circle of 6 to 8 spines at the apex, three or four scattered spines on tibia, and two slender short ones on tarsus.

Abdomen tapering very gradually, almost cylindrical to eighth segment. First and second segments slightly narrower than succeeding ones. Ninth segment only ½ as wide as eighth, tenth 2/3 as wide as ninth. Segments one to eight equal in length, nine shorter, and ten less than ½ as long as one to eight. Segments one to nine each bear a transverse row of six spines that increase gradually in length to the tip of the abdomen. Spines on ninth are almost as long as the segment itself. Ten bears four shorter, slender spines at the tip.

Prepupa.

Measurements.
Total body length .825 mm.

	Length, mm.	Width, mm.
Head	.06	.12
Prothorax	.135	.173
Pterothorax	.195	.255 (including wing pads)
Abdomen	.435	.31 at base.
		.24 at middle
		.105 at base of 9th segment
		.075 at tip of 9th segment

Spines near tip of abdomen, length .068 mm.

Color.- General color whitish yellow, sometimes light lemon-yellow. Body resembles that of second stage larva in

general, except that it is stouter as compared with its length.

Head (viewed from dorsal side) about twice as wide as long, with two long spines near bases of antennae and a transverse row of six spines behind the eyes. Eyes deep red in color.

Antennae translucent white, composed of five more or less distinct segments, segment one twice as wide as long, one two and four equal in length, five more than twice as long as four, three shortest. Three or four inconspicuous spines on the antennae. Segment one projects dorso-cephalad, two and rest of antennae project dorso-caudad over the head.

Prothorax wider than long, twice as long as head, broadly rounded in front, constricted at the middle of the sides. Four spines on each side increase in length from first to fourth, the fourth about as long as the fifth antennal segment. One spine on each side near middle of prothorax and a row of four recurved spines at posterior margin.

Mesothorax more than twice as broad as long, bearing the first pair of wing pads that extend to the middle of the second abdominal segment. There are two more or less irregular transverse rows of six spines each, one near the middle and the other near the posterior margin. The spines at the end of each row, borne by the wing pad are long, curved and prominent, the anterior one being shorter

and the second longer than the long spine at the posterior angle of the prothorax. A third long curved spine stands near the tip of the wing pads.

Metathorax about as wide as mesothorax and a little longer. The wing pa ds of the second pair of wings extend obliquely downward and reach the posterior margin of the second abdominal segment. Four spines are borne in the center of the metathorax.

Legs. The legs are moderately long and heavy. The femora of the forelegs bear two long spines on the outer side at the middle and three short ones at the tip. All the tibiae have two circles of five or six spines, one near the middle and the other towards the tip.

The abdomen widens from the base gradually to the 4th, 5th and 6th segments which are widest, and then tapers more rapidly to the ninth and tenth segments. Segments one to eight are about equal in length, the ninth is almost twice as long as the preceding while the tenth is minute dorsally but larger ventrally. Spines are borne on segments one to eight as in the mature larva. Those on segment one are very small. From three to eight they increase gradually in length until those on segment eight are $1\frac{1}{4}$ as long as the longest prothoracic spine. Segments three to eight are drawn out to a point that bears the long curved spines at each side. Segment nine bears a long curved spine at the middle of each side and four peculiar, recurved, short stout hooks at the posterior margin. Segment ten has four slender

curved spines.

Pupa.

Measurements.

Total body length .87 mm.

	Length, mm.	Width, mm.
Head	.06	.135
Prothorax	.105	.173
Pterothorax	.18	.27 (including wing pads)
Abdomen	.525	.195 at base
		.24 at middle
		.105 at base of ninth segment
		.075 at apex of ninth segment

Spines near tip of abdomen .075 in length.

Color. Translucent white, sometimes slightly yellowish. Body resembles that of the adult in general appearance, having the head relatively large and the abdomen tapering from about the middle to the tip. It presents a spiny appearance on account of the many long setae that are borne on all parts of the body.

Head. More than twice as wide as long, with two spines at the middle near the anterior margin; also two spines behind each eye. Ocelli absent. Eyes deep red in color.

Antennae. Translucent white, composed of seven segments. In the young pupae the segments are indistinct, but later on they become quite distinct. The antennae are bent back over the head, are closely applied to the head and prothorax and reach to near the middle of the latter. The first segment bears four rather stout, curved spines that project prominently and anteriorly. These and the spines

near the front margin of the head are nearly as long as the head (.045 mm.). The fifth segment bears three setae and the last two one each. Segment one extends dorso-cephadad, two dorso-caudad, and the rest of the antenna caudad.

Prothorax. More than one and a half times as wide as long, bearing four long slender spines on each side, of which the last are longest and also four long spines on the posterior margin.

Mesothorax. Very short and broad, bearing wing pads that extend to the end of the eighth abdominal segment. The mesothorax bears two spines near the middle and two on the posterior margin. The wing pads bear several spines, of which one near the base is long and curved (.075 mm.).

Metathorax is more than twice as wide as long, divided transversely into two equal parts and bears the wing pads of the second pair of wings that are closely applied to the under side of the mesothoracic pair of wing pads and are as long as these. Two long spines stand near the middle of the metathorax.

Legs. The legs are translucent white in color. Spines about the same as in the prepupal stage, but relatively much longer. Three short spines on each tarsus.

The abdomen has parallel sides for two segments, widens to third segment and tapers rather regularly from the fourth to the tip. Each segment bears a circle of twelve spines, six of which are dorsal and six ventral. The spines

increase gradually in length to the tip, those on the eighth segment are as long as the long spines on the wing pads. The ninth segment bears a row of six short spines dorsally at the middle, a long slender curved spine near each posterior (lateral) angle, and four peculiar recurved hooks on the posterior margin that are longer and more slender than those of the prepupa. The tenth segment is narrow and drawn out to a blunt point at the tip, and bears four slender curved spines.

Adult Female. For a detailed description of the female see Hinds' Monograph, Proc. U. S. Nat. Mus. Vol. XXVI pp. 179-181. Hinds gives the following color description: "Color quite uniformly light yellowish varying to brownish yellow." Most of the specimens on onions are darker, having the abdomen light brown. Those taken in various flowers, however, generally agree quite closely with Hinds' description.

LIFE HISTORY AND HABITS.

Oviposition. - The eggs are laid in the leaves and stems of the onion plants. The white narrow end of the bean-shaped, curved egg can be seen projecting slightly above the leaf surface. In the older eggs the bright red eyes of the embryo are conspicuous on the part of the egg that is visible. The egg is inserted with its long axis nearly perpendicular to the leaf surface. The greater part of the egg is therefore imbedded in the leaf tissue, as was observed by Miss Beach (Osborn, Ia., Bull. 27). Quaintance '98 states that "the eggs were deposited singly, just beneath the epidermis of the plant infested," and disagrees with Osborn's statement that they are imbedded in the cell structure. There is no doubt that the eggs are imbedded in the tissue and that they project slightly through the epidermis. Eggs are laid anywhere on the surface of the plant, apparently wherever the female happens to be feeding. They have been found in parts of the leaves that had not been fed upon, but usually they are common in the injured spots. On one occasion a female in captivity was seen in the act of oviposition. She already had the ovipositor inserted into the leaf for practically its whole length, so that 55 seconds -- the time that elapsed before the ovipositor was finally withdrawn -- does not represent the whole period of oviposition. After the complete insertion of the ovipositor the female strained three or four times, lifting the middle of the abdomen up and down, evi-

dently in order to force the egg out. In the field females were on several different occasions seen in the act of removing the ovipositor from the leaf suddenly with a jerk. No records were obtained as to the number of eggs laid by one female.

Length of the egg stage.- A number of attempts were made to obtain the length of the egg stage by placing females on onion plants covered with chimneys or bell jars and observing the emergence of the larvae. The results were not very satisfactory, first because it was difficult to obtain onion plants from the field that did not already contain eggs, and secondly because the plants soon outgrew the chimneys by which they were covered, especially when kept in the shade out of the frequent rains. The egg stage was found to vary from five to ten days. In the majority of cases it lasted for about ten days.

First Stage Larva.- Larvae were often seen emerging from the egg. Usually they were about half way out when first seen. The larva works itself free by slowly moving backwards and forwards. The legs and antennae are closely applied to the ventral surface of the body. As it emerges further and further the antennae and legs are gradually freed and move back and forth slowly. When two or three legs are free the larva does its best to bend forward far enough to reach the leaf surface with its feet. Finally it succeeds and has a foothold by means of which it

can pull the abdomen out of the egg shell. The order in which the legs and antennae became free varied considerably. Usually the antennae became free first. It is an interesting sight to see a larva with the tip of its abdomen still in the egg shell standing on the tip of its tail, so to speak, moving back and forth slowly, waving its antennae and kicking those of its legs that happen to be free from the body. As soon as it is finally free the larva runs off rapidly for a short distance and then looks for a place to begin feeding.

The newly issued larva is pure translucent white in color and seems to have the head, antennae, thorax and legs entirely too large for the diminutive tapering abdomen. Soon after feeding, however, the abdomen enlarges and takes on a greenish tinge due to the contents of the alimentary canal. After about a day the larva resembles the second larval stage very closely in general appearance.

The larvae, in both the first and second stages, have the habit of seeking out a sheltered part of the plant. Favorite places for them to congregate are between the leaves of the onion, at their bases, and on the under sides of leaves that are curled or bent over. When they are very abundant on a plant they may be found on almost any part, but sheltered places are preferred. The larvae do not ordinarily move about to any extent, but remain in one place. It was often noticed -- in the case of larvae confined in vials -- that an uninjured piece of onion leaf placed in

the vial would show a white spot of about one or two square millimeters after twenty-four hours. Evidently the larva moves but little after it finds a suitable feeding place. The white injured spot would be partly covered and surrounded by small black specks of excrement.

Length of First Larval Stage. - In four different cases larvae were seen either in the act of casting the larval skin, or found with the cast skin close by them or adhering to their bodies. No very marked change could be observed in the larva just after molting, the cast skin is very inconspicuous, and the larva moves off immediately after molting. These three reasons account for the fact that the larval molt was actually observed in only a few cases. In one case the larva molted two days after emerging from the egg. In the other three cases the larvae were taken in the act of molting and the time between the larval molt and the molt to the prepupa was respectively 4, 6 and 8 days. The total larval stage was found to vary from 5 to 18 days, with the average about 10 days. Probably, then, the first larval stage lasts from 2 to 6 days. In one case a larva was seen casting its skin. The old skin broke on the dorsal side, anteriorly, and remained on the leaf surface, while the larva "walked out of it". In a general way the molting was similar to the emergence from the egg.

Second Larval Stage. - In general appearance and

habits the larva of the second stage differs in no important respects from the first stage larva. It is more plump and heavy, and usually is of a deeper yellowish white color. When the larva is full grown and ready to pupate it stops feeding. About a day before transforming to the prepupal stage the greenish tinge of the abdominal contents disappears. At this time the larva has the habit of suddenly dropping from the leaf, or whatever surface it may be on, especially when it is disturbed. It is restless, running around on the sides of the vial in which it is confined, and usually refusing to remain on the leaf. Evidently in the natural condition the larva runs down the plant to the soil to find a suitable place for pupation, or it may drop to the ground from the leaf. Larvae confined in cotton-stoppered vials cast their skins and transformed to prepupae in various situations, - either on (or in) the cotton, between the cotton and the vial, in cracks in the cut end of the onion leaf, or on the bottom of the vial. When a small amount of loose muck soil was placed in the vial the larvae nearly always crawled into the soil to pupate. When an inch or so of soil was placed in a vial, the larvae went down to the bottom of the vial, i.e., an inch beneath the surface. They do not make a pupating cell or cocoon of definite form, but merely squirm around in the soil, moving the abdomen from side to side until a little cell is hollowed out. A few pupae were found in the field in the loose soil around the bulb of the onion

about an inch from the surface. In no case was a pupa found on the plant or even under the dry "scales" of the onion bulbs.

Prepupa.- When the second stage larva becomes full grown it ceases to feed and enters the loose soil at the base of the onion plant in order to molt and transform to the prepupal stage. The cast skin has a dirty white appearance and is usually found near to the prepupa. In general appearance the prepupa closely resembles the mature larva. It is usually of a yellowish white color. The wing pads are conspicuous, extending along the side of the abdomen to near the end of the second segment. The antennae project dorsally, bending backwards somewhat over the head. The spines on the body are placed in a general way as in the larva, but they are larger and more noticeable. The prepupa does not feed. It remains in one place, and only when disturbed does it walk around. The prepupal stage was found to vary from one to five days, the average of 44 individuals reared being 2.6 days.

Pupa.- About two and a half days after the transformation from the larva to the prepupa the prepupa casts a white inconspicuous skin and changes to the pupa. The pupa has a more spiny appearance than the prepupa. The antennae are bent down backwards over the head and prothorax and the wing pads extend to the end of the eighth

abdominal segment. The color is usually more whitish than that of the prepupa, except that the wing pads and some of the other parts darken up a day or two before the change to the adult. This stage is passed in the same place as the preceding. In activity the pupa resembles the prepupa very closely. The length of the pupal stage was found to vary from one to six days, the average of 44 individuals reared being 3.9 days.

Adult.- When the pupa is ready to molt and become an adult the skin splits on the dorsal side anteriorly and gradually sheds, the tip of the abdomen being the last part to be freed from the cast skin. The adult dries off in about half an hour; it is very light colored at first, being white with a slight yellowish tinge. Gradually the color darkens until in about two days the characteristic brownish-yellow color of the adult is attained. Apparently the adults live for six to eight weeks or more, as one female was kept confined in a vial for sixty days (August to October).

The adult is brownish-yellow in color, the abdomen a little darker, especially towards the tip, sometimes dark brown. The thorax has a slight orange-yellow tinge. The wings have a greyish appearance with the naked eye or under a hand lens. It is quite active, running rapidly especially when disturbed. The adult has the power of springing. It can fly well, although the abdomen has to

be raised up two or three times in succession before it can take flight. On one or two occasions the adults were seen flying over a badly infested onion field just before sunset. They could be plainly seen against the sky as minute specks.

Like the larvae the adults have a tendency to seek out more or less secluded places. They remain in one place to feed for a considerable length of time. This is shown by the fact that frequently, in the case of adults confined in vials, a small white spot covered and surrounded by excrement specks was found where the adult had been feeding during the previous twenty-four hours.

Usually the adults are found between the leaves at their bases, in the axils of the leaves, or on the under sides of the leaves, especially those that are bent over. They are however found on almost any part of the onion plant, and may be seen on all the leaves in exposed as well as protected places in the case of severe infestation. On hot days the thrips tend to avoid the direct rays of the sun, remaining mostly on the shady side of the leaf or stem.

Males.- Not a single male was found among about two hundred specimens mounted up and several hundreds examined carefully in alcohol. The material was collected at various times in the spring, summer and fall, and from

many different plants. The male of this species has been described by Packard '72 as a wingless form. (See Fig.). It is interesting to note that his description of this so-called wingless male of the onion thrips agrees very well with the mature larva of Aeolothrips fasciatus Linneaus that has been found to be predaceous on Thrips tabaci. Pergande '94 described the male of Thrips tabaci as follows: "This sex resembles the female in every respect, except that it is much smaller, narrower, and with the end of the body bluntly rounded. Its length is about 0.7 mm." Quaintance quotes the description of the male given by Lindeman, in 1888, and Hinds, in his Monograph ('02) quotes the description of the male of Thrips communis from Uzel's Monograph ('95).

In one experiment several females, reared from larvae taken in the field, were placed on an onion plant in order to study the egg stage. After the time ordinarily required for the egg stage had elapsed a number of larvae issued. Some of these larvae were reared, individually, to adults, mounted and determined as Thrips tabaci. For at least one generation, therefore, the species reproduced itself without the intervention of males. It seems safe to assume that it is normally parthenogenetic.

At least three other species of Thysanoptera have been found to be parthenogenetic. The grass thrips, Euthrips obscurus Müller (=Anaphothrips striatus Osborn) was bred parthenogenetically by Hinds, and also Heliothrips

haemorrhoidalis Bouche by Buffa (Redia, Vol. VII, fasc 1, 1911). No males of the pear thrips Physothrips pyri Daniel (= Euthrips pyri Daniel) have been found in California, although the life history of the species has been worked out in detail.

Number of generations.- At no time was it possible to distinguish definite broods of the onion thrips. Both larvae and adults have been found on onion plants from March 12th throughout the summer to November 19th. As the life cycle from the egg to the adult requires about 26 days, there are probably from five to six generations from May to September.

Hibernation.- Osborn and Mally '95 stated that "in all probability the winter is paased in the larval or adult form, both stages being represented during the winter months." Lintner '95 quoted the foregoing statement. Uzel '95 said of Thrips communis Uzel that " the females hibernate in dry flower heads, under fallen leaves and in lawns." Webster '01, on the basis of observations made in the field in August, September, October, December, January, February, March and April, stated that "here in northern Ohio, the insect passes the winter in the larval, pupal and adult stages, the first predominating, and may be found in matted grass or in the tops of onions left out in the fields at the time the crop is gathered. He "had no trouble in finding the insects in the field

during the winter days when the temperature was 35 to 38 degrees Fahrenheit, even after it had previously fallen to several degrees below zero." Davis 'll also said that "thrips hibernate in weeds and grasses along the edge of onion fields."

At the end of September, 1912, larvae and adults were present on the onion tops left on the fields at Canastota, N.Y. On November 19th most of the tops cut off at harvest time had withered up entirely, but both adults and larvae of Thrips tabaci were found on onions that had been left growing on the fields. Matted grass collected from the ditch-banks of onion fields when sifted yielded two adult females of Thrips tabaci. The same fields were again visited on March 12, 1913. The ground was wet and there was some snow, although the temperature was probably not below 40 degrees Fahrenheit. Considerable matted grass was collected in paper bags from the ditch-banks and also some grass and weeds from the fields. Later this material was carefully sifted over in the laboratory, but no Thrips tabaci were found.

Aptinothrips rufus Gmelin and its variety connaticornis and small yellowish larvae that probably belonged to this species were quite common in the siftings. One or two specimens of Euthrips obscurus Müller were also taken. Several adults and larvae of Thrips tabaci were found on onion plants that had remained green over winter on last year's onion fields. They were found pretty well down

towards the base of the plants, beneath the leaves and beneath the leaf-sheaths. Many of the adults and larvae were dead. Those that were alive moved slowly, and seemed to be in an inactive quiet state. Later these same individuals became normally active when kept in a warmer place in vials.

On April 2 and 3, 1913, some of the onion fields, at Florida and Chester, in Orange County were visited. Onion plants could be found only in scattered places on the fields. At Chester several adults and larvae were found on some onion plants of the previous season in a field that had been badly infested. A considerable amount of matted grass, both green and dry, was collected into paper bags and sifted. Aptinothrips rufus and a few Euthrips obscurus were found, but no Thrips tabaci.

At Ithaca on the Hook farm on West Hill, adults and young and old larvae were taken on May 3d on onion plants that had been growing in the field all winter. Evidently, then, Thrips tabaci passes the winter in the larval and adult stages. Whether the larvae found in winter and early spring live through the winter as larvae or whether egg laying and the issuing of larvae go on during the winter months has not been determined.

The observations of Webster '01 that larvae (pupae?) and adults may be found in matted grass during the winter are supported by the fact that the species is ~~known~~ found on several different plants in the summer and by the further

consideration that, ordinarily, there would scarcely be enough green onion tops left on the fields to furnish sufficient food for the thrips to maintain themselves during the winter.

REARING OF THRIPS TABACI LIND.

From July until the end of September, 1912, individual records were kept of the length of the stages of the onion thrips. For this purpose the thrips were confined -- singly-- in neckless cotton stoppered vials (size 64 by 22 mm.). A piece of onion leaf or stem about an inch long was placed in the vial and changed as often as necessary, usually every day. The larvae were taken from plants in the field or from plants kept for records of the egg stage. Newly issued larvae could readily be obtained by keeping leaves which had been injured by thrips in water and removing all the larvae daily. On account of the comparative inactivity of the larvae they could not conveniently be made to walk from the old to the fresh leaf. A satisfactory method of transferring the larvae was to use a small camelshair brush slightly moistened at the tip.

Difficulties.- In rainy weather there was a tendency for the moisture, evaporating from the onion leaf, to collect on the sides of the vials. Larvae that got stuck in the moisture would die if it did not dry off within a few hours.

If the thick part of the leaf was used the cut surface and inside offered many cracks and crevices into which the larvae liked to crawl. In hot weather the thin part of the leaf often wilted and curled up, and then it was difficult to find and transfer the larvae if they happened to be inside the hollow leaf.

The first one or two days after a newly issued larva was

confined in a vial was the period during which most of the individuals were lost. Often the larva would wander off the leaf, and the next day it would be found on the cotton or on the side of the vial. When this happened the larva would frequently die in a few days even if it remained on the leaf. Not infrequently the newly issued larvae could not be found the day after they were taken. This was probably due, in part at least, to their hiding in the cotton or in the crevices in the leaf.

Comparatively little difficulty was experienced in rearing the larvae after they were four or five days old. The adults could be kept alive easily in vials on onion leaves for several weeks.

Early in the season two species, Thrips tabaci and Euthrips obscurus were present on the onions. For this reason most of the adults reared through from the larval stage were mounted up for determination, so that it could be definitely ascertained for what species the records of the length of larval and pupal stages had been obtained.

In all seventy-five individuals were successfully reared to adults. The records obtained from twenty-six of these have not been included in the following tables for one or more of the following reasons: (1) the larvae were not newly issued when taken, (2) they were not examined every day and the time records are therefore not sufficiently definite, or (3) the records are so far from the average as to be

evidently abnormal or erroneous.

Thirty-two of the seventy-five individuals were mounted and determined as Thrips tabaci. The remaining seventeen were not mounted, but they have been taken into consideration in the table because they were definitely recognized as Thrips tabaci.while alive by their activities and appearance, and also because the records obtained from them agree closely with those of the determined specimens.

REARING RECORDS.

Specimens		Range in days	Average length of stage. No. of individuals.	days.
Larva 1st & 2d stages	Determined	8 to 11	21	9.52
	Undetermined	8 to 12	17	9.29
	Aggregate	8 to 12	38	9.42
Prepupa	Determined	1 to 5	27	2.63
	Undetermined	1 to 5	17	2.53
	Aggregate	1 to 5	44	2.59
Pupa	Determined	1 to 6	27	3.52
	Undetermined	2 to 6	17	4.53
	Aggregate	1 to 6	44	3.91
Prepupa and Pupa	Determined	4 to 9	27	6.15
	Undetermined	5 to 10	17	7.96
	Aggregate	4 to 10	44	6.50
Larval & Pupal	Determined	14 to 18 in 21	Average	
	Undetermined	14 to 22 in 17	14 to 22 days.	
Adult	Determined - one kept alive 56 days.		Maximum	
	Undetermined - one kept alive for 60 days		60 days.	
Total from egg todeath of adult	Determined - maximum 70 days		Maximum	
	Undetermined - maximum 75 days		75 days.	

Summary of the Length of the Stages.

The Egg Stage varied from 5 to 10 days, average about 10 days.(?)

First Larval Stage varied from 2 to 4 to 6 days, average about 2 days. (?)

First plus Second Larval Stage varied from 8 to 12 days, average about 9½ days.

Prepupal stage varied from 1 to 5 days, average about 2½ days.

Pupal stage varied from 1 to 6 days, average about 4 days.

Prepupal plus Pupal stage varied from 4 to 10 days, average about 6½ days.

Larval plus Pupal stages varied from 14 to 22 days, average about 16 days.

Total life cycle from egg to adult:

egg	10 days
larva	9½
prepupa and pupa	6½
	26 days.
Maximum length of life of adult	60 days
Total	86 days.

FOOD PLANTS.

Thrips tabaci has been recorded upon the following food plants:-

onion, tobacco, (Russia and Italy), potato, tumbleweed, (California), cabbage, cauliflower, kale, sweet clover, melons, cucumbers, parsley, leeks, carnations (?), stonecrop, heal-all, blanket flower, cinquefoil, nasturtium, candytuft, squash, four o'clock, turnip, catnip, Rudbeckia,mignonette, cone-flower, tomato, Jamestown weed, crab grass, pear (Sweden), beans (Tasmani and pumpkin (Tasmania), jimson, plum, timothy, wheat, mullein, shepherds purse, Rubus, Erigeron canadensis, dandelion, Stellaria, Specillaria. Cobelli '09 found the species in 18 flowers in Italy. Moulton '11 stated: On "almost all wild and cultivated flowers, grasses, fruit blossoms and truck crops."

Last summer adults were collected from the following: onion, cauliflower, cabbage, buckwheat flowers, wild mustard, daisy, wild carrot, rhubarb flowers, potato, pigweed, yellow rocket, buttercup, grass and clover. In greenhouses on chrysanthemums, cucumbers and castor oil plant and in carnation flowers.

Adults were bred from larvae found upon onion and cauliflower.

In Europe the species is a serious tobacco pest, but so far it has not been recorded as occurring on tobacco in the United States.

Webster '01 said that, according to Mr. Edwards,

yellow onions are more liable to injury than the red or white varieties.

DISTRIBUTION.

The onion thrips is apparently a cosmopolitan species. Hinds '02 gave the following distribution for the world: Russia (Lindeman), England (Shipley)*, Italy (Targioni-Tozzetti), Bohemia, Helgoland (Uzel), Bermuda, Southern Canada, United States. Injury to onions by thrips had also been reported from Germany (Pergande '94), Sweden (Trybom '99) and South Africa (Fuller '01). Since 1902 Australia (Froggatt '06) and England (Bagnall '08) have been added to the list.

Hinds stated that Thrips tabaci had been reported from the following localities in the United States:- Massachusetts, Connecticut, New York, Long Island, Pennsylvania, New Jersey, District of Columbia, Virginia, Florida, Kentucky, Ohio, Indiana, Illinois, Iowa, Michigan, Colorado, California. To this list should be added Arizona (Crane and Forbes '08) and Texas (Beattie '09). Moulton '11 said that the species was "generally distributed from Maine to California."

* I have been unable to find the record given by Hinds as: England (Shipley). The only paper by Shipley in Hinds' bibliography is:"Bull. 10 Misc. Inf. Roy. Gardens, 1887" and it deals only with onions on Bermuda.

ECONOMIC IMPORTANCE.

In the summer of 1912 the species was found in greater or less abundance on onions at Ithaca, Canastota, Elmira, Marion (Wayne County), and in Orange County (Chester and Florida). During August some of the fields at Chester and Florida were so heavily infested as to have a white, blighted appearance as a result of the injury to the leaves. In the other localities above mentioned the infestation was slight. According to Mr. Jennings, of Canastota, the serious outbreak in 1910 had reduced the onion crop in his section by one half. About ten years before the thrips injury had attracted attention for the first time.

In 1911 there had evidently not been sufficient injury done by the species to attract the attention of the growers. Although the infestation was exceedingly heavy in Orange County towards the end of the summer, the thrips had evidently not been sufficiently abundant early in the season to cause a very serious loss. The effects that they did produce undoubtedly lessened the value of the crop, but the growers seemed to consider the crop a fairly good one nevertheless. Ever since Packard's first record of onion thrips injury in 1872 it has been noticed by entomologists and growers that the worst injury is usually done in dry hot weather. At Canastota thrips were present in greater or less numbers in almost every field, but their work was not prominently noticeable on account of the large, heavy, green tops that the plants developed, favored by the cool moist season. A given number of thrips working on a plant

stunted by hot dry weather would naturally do more damage than the same number working on a large healthy plant. The conclusion is that it would be difficult to decide just how much thrips were to be blamed for the partial failure of the onion crop reported occurring in dry hot seasons.

The onion maggot (Phorbia ceparum Bouché) and the onion smut are two serious obstacles to onion growing both at Canastota and in Orange County that further complicate the estimation of damage done by the thrips.

Webster '94 reported that injury was worse on higher lands than on muck soil, especially on clay.At Canastota thrips were fairly abundant in an onion field that was partly muck soil and then ran out into a gravelly loam on one side. It was very apparent that the injury by the thrips was worse on the gravelly soil, and especially on plants growing in places where the clay subsoil had been thrown from the bottom of a deep ditch nearby. However, the apparent greater injury was due merely to the fact that the plants growing on the muck soil were much more vigorous and had a greater leaf surface.

According to the opinions of various growers and the observations made during the past season the most serious injury is in all probability done when the thrips become very abundant in June and July when the plants are still in the actively growing period. In the case of vigorous plants a moderately severe infestation, coming at the time

when the onions are nearing maturity, would probably not do serious damage.

Considering the fact that at Canastota alone there are in the neighborhood of a thousand acres of onions raised every year and probably twice as many in the Florida section of Orange County, the onion thrips can, in seasons favorable to it, become a very serious pest.

NATURE OF THE INJURY.

Thrips injure the plants upon which they feed by removing the sap from the cells beneath the epidermis, thus producing dry white spots on the leaves. In severe infestations the greater part of the leaf surface of the plants is turned white, hance the names "white blast" and"blight" often applied to thrips injury.

A different effect is produced where thrips feed upon very tender young leaves. Young leaves in the "heart" of the onion plant, where thrips larvae often congregate in large numbers, evidently grow so rapidly that the characteristic white spots are not produced by the thrips feeding upon them. Later these leaves are conspicuously curled inwards and downwards. Probably the curling results because the uninjured outer surface increases in length more rapidly than the injured inner surface. The inner surface of such curled leaves has a smooth, thickened appearance. This form of injury is comparable to that produced by the orange thrips (Physothrips citri Moulton) and the pear

thrips (Physothrips pyri Daniel) upon tender leaves of their respective host plants.

Cabbage and cauliflower leaves turn brown instead of white when they are seriously infested by thrips. In the case of carnations in greenhouses the thrips seem to enter the flower buds as soon as they begin to open, and feed upon the tender inner parts of the flower. The result is that when the bud is fully expanded, the flower is misshapen, brownish and partly shrivelled.

THE PROCESS OF FEEDING.

The mouth parts of thrips are fitted for sucking. They consist of three slender stylets enclosed in a cone that extends downwards and backwards from the hind margin of the underside of the head. The mouth opening is a small opening at the tip of the mouth cone through which the stylets can be protruded. The edge of the mouth opening is soft, so that it can be closely applied to the leaf surface. The anterior end of the esophagus forms a pumping organ that serves to draw the plant juices into the esophagus.

In feeding the mouth opening is pressed tightly upon the leaf surface. The stylets move downwards, out through the mouth opening, and pierce the epidermis. Probably the shorter, heavier unpaired stylet serves to rupture the tough epidermis, while the more slender, paired stylets extend down deeper to pierce the underlying cells. The

plant juices are sucked up by means of the pumping organ of the esophagus through the more or less air tight cavity of the mouth cone.

Several authors have stated that the epidermis of the leaf is rasped or scraped off by the thrips in feeding. There are a few short spines at the tip of the cone that may be used to some extent to scrape the leaf surface. I often observed Thrips tabaci in the act of feeding, but I never noticed any movement of the cone over the leaf surface. If an injured spot on an onion leaf is examined under the microscope the epidermis is seen to be present upon it and intact except for the punctures made by the thrips in feeding. The epidermis can be stripped from an injured spot about as readily as from an uninjured part of the leaf.

It seems clear then that thrips feed by piercing the epidermis of the leaf with their mouth stylets and sucking the juices from the underlying cells.

CONTROL.

Natural conditons. - It is a well known fact that dry, hot weather is favorable for the rapid development and increase of the onion thrips. This has also been found to be the case with the orange thrips (Physothrips citri Moulton) in California. Growers seemed to agree that hot, dry summers were the only times when thrips injury became severe enough to do appreciable damage to the crop. As has been pointed out above the relatively less vigorous growth of the plants themselves in hot, dry seasons may account, in part at least, for the greater injury done in such seasons.

Many entomologists have also written that frequent heavy showers during early and mid-summer play an important part in the control of the thrips. Evidently thrips larvae and adults would be washed from exposed parts of the plants by showers. From observations made during the past summer it would seem that the rain was an important factor in keeping the thrips in check. On August 1, 1912, an onion field at Chester, N.Y., was literally swarming with thrips larvae and adults. Up to that time there had been practically no rain. When the fields were revisited on the 14th there was a marked decrease in the number of thrips on the plants. The ground was still wet from recent rains, and in all probability the decrease in number of thrips upon the plants was due to the rains.

Enemies of Thrips tabaci.- Webster '94 reported that

the common spotted lady bug Megilla maculata De G. and the larva of an undetermined species of syrphus fly had been observed to feed on the onion thrips. Quaintance '98 found that both the nymphs and adults of an anthocorid, Triphleps insidiosus Say, commonly fed on both Thrips tabaci and Thrips tritici Fitch (= Frankliniella tritici Fitch). He also found larvae of a species of Chrysopa feeding on thrips and obtained a nematode from the abdomen of thrips that may have been parasitic. Pettit '99 reports and figures a gregarinid parasite that was found in black shrivelled larvae of Thrips tabaci, and reported ('99 b) that the numbers of thrips had been greatly reduced by the multiplication of this parasite. Garman '01 reported Empusa planchoniana as a fungus enemy of the onion thrips.

Russell '11 and '12 reported that a minute chalcid Thripoctenus russelli Crawford had been bred from prepupae of Thrips tabaci larvae collected in the field in California.

Last summer several predaceous enemies of Thrips tabaci were found feeding on it in various localities:-

Aeolothrips fasciatus Linnaeus was found to be predaceous on Thrips tabaci in its larval stages. It is discussed separately later.

Megilla maculata De G, the common spotted lady bug was frequently found in Orange County and at Canastota on onions infested with thrips and it was observed on one occasion to actually feed on Thrips tabaci larvae. Eggs

of coccinellids were quite common on thrips infested onions, and the larvae reared from them fed on thrips larvae in a breeding vial. Presumably then this species is predaceous on thrips both as a larva and as an adult. Two other species of lady bugs were also taken on the onions but much less commonly, namely Hippodamia parenthesis Say and Hippodamia convergens Guer. It is probable that these two species were also preying upon the thrips.

The larvae of , a syrphid fly, were often taken in the field, feeding on thrips larvae, especially down between the bases of the leaves of the onion.

Reduviolus ferus L. a nabid bug was quite abundant in a thrips-infested onion field at Canastota. Both the nymphs and adults preyed upon larvae and adults of Thrips tabaci, and three individuals were reared from half-grown nymphs to adults largely on thrips. When there was not sufficient thrips material at hand they were fed on aphids.

Triphleps insidiosus Say.- On August 15 some badly thrips-infested onion plants were brought from Chester, N.Y., to Canastota and kept for about two weeks, when several young nymphs of this species, that had evidently issued from eggs laid in the plants, were found on them. Several of these were reared to adults, on a thrips-larva-and-adult diet. A young nymph taken on September 2 molted four times, the last molt being to the adult, on September 21. It destroyed at least thirty thrips larvae and probably many more. The species was found on various flowers and a spec-

imen was seen once with a thrips stuck on the end of its beak on a flower at Ithaca in October.

Chrysopa.- Eggs of a species of Chrysopa were not infrequently found on onion plants, and larvae were on several occasions seen to feed on Thrips tabaci and were kept alive for about two weeks on thrips larvae.

From this list of insects feeding on Thrips tabaci it is safe to conclude that the various predaceous enemies of the species play an important part in keeping it in check.

Artificial Control.- Various contact insecticides have been recommended as remedies for the onion thrips since Packard's first record of the species. Kerosene emulsion seems to have been mentioned more frequently than any other material. Whale oil soap, "Rose Leaf Insecticide", crude carbolic acid, tobacco water, pyrethrum and white hellebore have also been used in experiments in the control of the species. There are no published records of extensive experiments with the use of insecticides. Osborn-Mally '95 found kerosene emulsion most effective. Quaintance '98 recommended whale oil soap (1 lb. to 4 gals.) and "Rose Leaf Insecticide" (1 lb. to 4 gals. water.) Webster '01 had best success with whale oil soap solution (1 lb. to 8 gals. water.) In an unpublished "Memorandum on Onion Thrips" 1910, Mr. F. N. Chittenden of the Bureau of Entomology reported that the best success, in the experience of field agents of the Bureau, had been obtained with a

combination of nicotine sulphate and whale oil soap. The formula was

Nicotine sulphate..... 10 ounces
Whale oil soap..... 5 ounces
Water..... 50 gallons.

At least three sprayings were necessary.

Mr. Chittenden also recommends dipping the sets in nicotine sulphate solution before planting them.

Spraying.- There are several difficulties that will be encountered in spraying onions to control the onion thrips. The habit of the larvae and adults of seeking out protected places, in leaf sheaths and on the under side of leaves necessitates very thorough spraying. Another trouble is to find a machine that will spray several rows of onions at once and spray with sufficient pressure to force the spray into the hiding places of the thrips. As the rows of onions are about 15 to 18 inches apart it is doubtful whether a horse rig could be used. Wheelbarrow sprayers have been used with reasonable success by some growers. As was suggested by Mr, Chittenden in Circular Letter E on the onion thrips (1909) it would be advisable to spray early in the season when the plants were small so as to prevent injury. Considering the great variation in the abundance of the species from year to year it would be rather difficult to judge as to whether the infestation was going to be heavy enough to warrant spraying.

In view of the experience of growers and experimenters, however, the thrips can probably be held in check if the

plants are thoroughly sprayed early in the summer with a tobacco solution in combination with soap. In fumigation of greenhouses against thrips Fernald-Hinds '00 obtained the best results by using "Nikoteen." Hydrocyanic acid gas was recommended by Davis '11.

Cultivation.- Many writers have advised clean cultivation as a means of preventing injury by the onion thrips. Webster '00 reported that there had been less injury done by the species in places where the surroundings were cultivated and free from grass. Collecting and burning all tops, culls and other waste material from the fields after the harvest has been strongly advised. It has been noticed that the infestation spread from the margins of the onion fields towards the center. As the fields are plowed in the fall or spring, and since there are usually very few onion tops left on the fields it seems natural to suppose that the thrips come on to the fields from surrounding grass fields or ditch banks.Cultural methods are undoubtedly valuable as a general practice and are probably also of use against the onion thrips. However, as Fernald-Summers '10 point out, these methods have not been tried long enough to permit a definite statement as to their value.

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[a] (Note).- A question mark preceding a reference indicates that the insect discussed may not be Thrips tabaci. I have not seen the references preceded by an asterisk (*).

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Thripoctenus russelli Crawf. parasite of Thrips tabaci.

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AEOLOTHRIPS FASCIATUS LINNAEUS.

AN ENEMY OF THRIPS TABACI LINDEMAN.

Aeolothrips fasciatus is a large black species belonging to the family Aeolothripidae. It is quite conspicuous on account of the three white bands on the wings and its habit of running around rapidly. The adult was known to Linnaeus and Haliday described the larva in 1836, but apparently nothing has been published on the biology of the larva either before or after Reuter's paper in 1902.

In the summer of 1912 the larvae of this species were commonly found preying upon the onion thrips. The adults had been noticed on onions for several weeks, but their relation to the onion thrips was not surmised until a predaceous larva, found feeding on a thrips larva in the field, was reared to an adult that proved to be Aeolothrips fasciatus.

HISTORY.

This species was described by Linnaeus in the tenth edition of his Systema Naturae in 1758 and named Thrips fasciata. It was known to entomologists by this name until Haliday, in 1836, placed it in a new genus Aeolothrips and the subgenus Coleothrips. Haliday also described the larva for the first time. Burmeister '39 referred to this species as Aeolothrips fasciata. In 1855 Fitch found it common on wheat; he described it as new under the name Coleothrips trifasciata. Various authors have since referred to it under one of the above mentioned names. Webster '87

found it common on buckwheat in Ohio, and Thaxter '90 believed that it caused a rust of oats in Connecticut. In 1893 Gillette reported it as occurring commonly on onions with the onion thrips (Thrips striata Osborn?). Various authors have recorded it on celery, clover, alfalfa, sunflowers and many other plants. Hinds '02 redescribed the species, quoting Haliday's description of the larva. In the same year Reuter published the only paper on the biology of the larva that I have been able to find. Reuter '02 gave a short critical review of what had been written on predaceous Thysanoptera by Walsh, Riley, Pergande and Bohls. He added a ~~parth~~ fourth predaceous species to the list of carnivorous thrips by publishing his observations on the habits of the larvae of Aeolothrips fasciatus. He took a number of the larvae of this species on smooth pigweed (Chenopodium album) on which Thrips tabaci was abundant, and found that the Aeolothrips larvae fed exclusively upon the larvae and adults of Thrips tabaci. In a series of rearing experiments he confined a number of Aeolothrips larvae in vials, either alone, or with Thrips tabaci adults or larvae, with pieces of the "host plant", or with plant lice, small caterpillars, and heteropterous nymphs from the "host plant". The results were: (1) the larvae fed upon the larvae and adults of Thrips tabaci and thrived well; (2) they died after a few days under all of the other conditions. The following is a free translation of his conclusions (pp. 80-81).

"From this table (of results) it follows that the

that the larvae of Aeolothrips fasciata (1) always refused vegetable food, (2) were exclusively carnivorous, (3) did not sieze and suck the juices from any of the animals offered to them as food except individuals of Thrips communis, both larvae and adults, and (4) did not attack one another and thus did not exhibit cannibalism (sensu strictu) -- in contrast with the habits of Anthothrips aculeata Fabr." Reuter found that a pretty well mature larva of Aeolothrips would suck out, on the average, from 7 to 8 larvae and adults of Thrips tabaci in a day. He stated that, although the larvae reared by him were always carnivorous, proof had not been furnished that the species is carnivorous under all circumstances. The following facts were mentioned by him as indicating that the predaceous habit was normal for the larvae at least:- (i) The larvae refused to feed upon the plant upon which they had been taken; many truly herbivorous thrips fed upon several different plants. (ii) The larvae refused to feed upon all of the animals found with them on the Chenopodium except Thrips tabaci. This seemed to indicate a fairly well established fixity of the carnivorous habit. (iii) The rapid movements of the larvae, the rapidity with which they overpowered their prey, and their large well developed maxillary palpi all tend to give them the appearance of true beasts of prey.

Reuter had also taken the larvae of Aeolothrips on grains, but always singly, scattered here and there among the more abundant larvae of other species of thrips (Physopus

tenuicornis Uzel and Limothrips denticornis Haliday). He assumed that the larvae preyed upon these other species of thrips, but made no observations on this point. The only adult of Aeolothrips was at once preserved in alcohol, so that no experiments could be performed to determine the feeding habits of the adult.

The observations that I made last summer agree with the conclusions at which Reuter arrived, except that I found the larvae cannibalistic in my rearing vials.

Since 1902 several authors have mentioned the species, recording it from new localities and listing its food plants. Cobelli '09 gave a list of no less than twenty-two flowers in which he had found it.

DISTRIBUTION AND FOOD PLANTS.

Like some other species of Thysanoptera Aeolothrips fasciatus is quite cosmopolitan. It has been reported from Austria, England, Holland, Finland, Germany, Bohemia, Italy, Portugal, Russia, Africa, and in the United States from New York, Indiana, Connecticut, New Mexico, Michigan, Colorado, Iowa, California, Oregon and Ohio.

Linnaeus stated that his Thrips fasciata lived in flowers. Haliday found it in various flowers, especially Reseda. Uzel stated that it was found in many flowers, especially those of Linaria vulgaris. Hinds '02 listed the food plants as follows:- alfalfa, buckwheat, celery, clover, Compositae, oats, onion, tansy, wheat, various grasses and weeds. It has also been recorded upon the

following:- wild sunflower (Gillette), California Buckeye, monkey flower and sugar beet foliage (Moulton '11), Chrysanthemum leucanthemum (Bridwell in Oregon) and on barley (Straňák '12). Cobelli '09 found it on twenty-two flowers in Trentino, Italy.

During 1912 I collected the adults of this species on the following plants: onion, leek, corn, clover, pigweed, oats, grass and dandelion.

DESCRIPTION.

Larva. First Stage.- The newly issued larva is white in color, with the body slender, the abdomen being comparatively small. Soon after feeding the color changes to a yellowish white, the abdomen being deep yellow on account of the orange yellow contents of the intestine.

Measurements.

(taken from a young larva preserved for several months in synthol).

Total body length 1.02 mm.
1.26 mm. in an older larva of this stage

	Length mm.	Width mm.	
Head	.081	.108	
Prothorax	.144	.16	(greatest)
Pterothorax	.216	.18	
Abdomen	.576	.06	segment 1
		.18	segment # 4 & 5
		.126	segment 8
		.054	segment 10 at base
		.027	segment 10 at apex.

Total length of antenna .25 mm., width about .04 mm.

Total length of a middle leg .25 mm.

Length of spines at tip of abdomen .16 mm.

Head small, slightly more than two thirds as long as wide, with the cheeks parallel and the front drawn out to a broadly rounded point. Eyes bright red, small, situated at about the middle of the dorsal side of the head. Two strong spines stand between the eyes, one behind the base of each antenna. A pair of similar spines on the anterior margin, closer together. Two outward-curved grey lines (ridges?) separate the bases of the antennae.

Lateral aspect of head: distance from vertex to tip of mouth-cone almost twice the length of head; the longest axis of the head perpendicular to the long axis of the body. Front of head arched, bearing three pairs of spines, of which the middle pair is the longest, while the third is situated at the base of the mouth cone. A pair of similar spines on the labium. Mouth cone large and prominent, almost as broad as head at base. Maxillary palpi three segmented, standing away from the mouth cone at the sides, while their tips are directed inwards towards the tip of the cone.

Antennae rather stout, arising from the dorsal side of the head, between the eyes but in front of a line drawn through them, seven segmented, about three times as long as the head, and one seventh as wide as long.

Segment one short, as wide as long, with one bristle at the middle; two as wide as one, barrelshaped, three as long as five, cylindrical, constricted for a short distance at the base, the two bristles near the tip much shorter than those on two; four shorter than three and five, narrowed at each end, with two bristles at tip as long as those on three; five at tip about as wide as two, tapering gradually from apex to base, with two bristles near tip on outside; six a little more than half as wide as five, borne on the inner angle of the latter; seven narrower than six and one third longer; seven bears three slender bristles at its tip; six and seven together as long as four. Segments two to seven are annulated, greyish white in color.

Prothorax about as wide behind as it is long, narrower in front, sides straight. A curved transverse row of four spines just before the middle, and a row of six long spines near the hind margin, in which the spines at the sides are longer than the others; one spine at the sides between these two rows.

Mesothorax rectangular, wider than long, with two spines at the sides near the middle, and a row of four near the hind margin that are about as long as those on the middle of the prothorax.

Metathorax about equal to the mesothorax, with a row of four spines near the hind margin that are shorter than those on the mesothorax, and two small spines near the center of the sides.

Legs long and stout. Several scattered spines on the femora and tibiae, and two longer ones near the tips of the tibiae on the outside.

Abdomen rather long and slender, widening gradually from the first to the fourth and fifth that are widest, and tapering gradually from there to the eighth. Segments nine and ten are much narrower than eight, tapering rapidly to the narrow tip of the tenth. There is a transverse row of six spines above, near the middle of segments one to seven. They gradually increase in length to the seventh, where they are as long as those on the prothorax. Two short spines on the ventral side of segments one to eight. Six spines on the top and sides of segments eight and nine about one third as long as the whorl of six long slender

spines on the tenth segment.

Color. Upon issuing the larva is white. After feeding the color of the head, legs and thorax (in part) becomes light yellow, and that of the abdomen orange yellow to light orange.

Larva. Second Stage.

Measurements. (specimens preserved in synthol for several,months; large, about ready to pupate.) Total body length 1.926 mm. (1.48 mm. in a younger second stage larva.)

	Length mm.	Width mm.	
Head	.099	.126	
Prothorax	.198	.18	
Mesothorax	.216	.27	
Metathorax	.18	.306	
Abdomen	1.206	.338	(greatest)

Width of abdominal segments:- one .306 mm.; four and five .338mm.; seven .288 mm.; eight .234 mm.; (greatest);nine .117 mm. (greatest); ten .072 (base); .036 (apex). Antenna, length .288 mm.; width .03 mm. (approximately). Hind leg, length .306 mm. (femur and tibia); width .036 mm. (approximately).

General appearance like that of first stage, except that abdomen is relatively much larger, and the head, prothorax, legs and antennae are relatively smaller. Color deeper yellow, with the abdomen orange yellow, sometimes orange.

Head almost one third wider than long, shaped as in first stage. Maxillary palpus three segmented, relative

lengths of the segments:- one 4; two 6; three 5.

Antennae more slender, comparatively, than in first stage. Segment one stout, sub-cylindrical, two longer and narrower than one, smoothly rounded at apex, wider than at the base; three much narrower than two, longer than one and two together, joined to the latter by a short narrow stalk, somewhat narrower towards the tip; four three-fourths as long as three, and about as wide; five narrow at base and widening to tip where it is almost as wide as two; five as long as four; six and seven together two-thirds as long as five, half as wide as tip of five; seven two and one-half times as long as six, slightly narrower, its tip broadly rounded; six about as wide as long.

Bristles.- Two on segment one longest, three at tip of two, four near tip of three and four, three as long as those on two on five on outside, two rather stout ones on six, three on tip of seven and two near tip. Segments three, four, five and seven prominently annulated. Color greyish white.

Prothorax as in first stage, but smaller as compared with the mesothorax, metathorax and abdomen.

Mesothorax bears two transverse rows of six spines. It is broader behind than in front, with the sides smooth.

Metathorax with a transverse row of four spines and another of six spines behind. It is more or less rectangular with the sides evenly rounded.

Abdomen as in first stage, but relatively larger and heavier. Spines as before the molt except that eight spines

show on each of the segments dorsally. Segment nine bears four peculiar short, stout spines on the dorsal side that are not present in the first stage, and two long slender spines at the sides. The six spines on the tenth segment are inconspicuous, being much shorter than those on the eighth or ninth.

Legs as in first stage, but not so strong compared with the size of the body as in the first stage.

Haliday described the larva as follows:-
"Larva yellow, the abdomen behind deeper orange, a whorl of hairs on each segment, more conspicuous on the last two: prothorax elongate: antennae shorter than in the perfect insect, the number of joints similar: mouth nearly perpendicular, not inflected under the breast: joints of maxillary palpi not very unequal."

Burmeister described it as follows:-
"Die gelbe Larve hat an jedem Ringe des nach dem spitze zu dunkleren Hinterleibes einen Haarbüschel, der besonders am letzten sehr gross ist; der Vorderbrustring ist länglich; die Fühler sind kürzer, aber gleichfalls scheinbar 5-gliedering; der Mundfortsatz steht ziemlich senkrecht, die Kiefertasterglieder fast von gleicher Grösse."

Packard '72 described what he took to be the male of Limothrips tritici (= Thrips tabaci ?), but from his description and figures (see fig.) there seems to be no doubt that he mistook the larva of Aeolothrips for the male of his Limothrips tritici.

"The females alone are winged, the males being wing-

less and closely resembling the larvae. ... The male differs from the larva in having 2-jointed feet (tarsi) and 7-jointed antennae, those of the larva being 4-jointed. The second joint is exactly barrelshaped, with two ridges or lines surrounding it; third and fourth joints long, ovate, the third being a little larger than the fourth, and with about twelve transverse lines, there being about eight on the fourth joint, from the end of which projects a remarkable tubercle, as seen in the figure. The fifth joint is square at the end with about eleven transverse lines, and three or four stout hairs externally; sixth joint minute and spherical, while the seventh is three times as long as the sixth, and is finely striated and with four unequal stout hairs. It is just twice the length of the female, measuring .08 inch."

Prepupa. (Description made in field).

"Color.- Head and prothorax pale lemon yellow. Eyes very deep red, almost blackish. Pterothorax yellow, of deeper color than that of head and prothorax. Abdomen: Segments one to eight deep orange yellow, with a reddish tint in places. Ninth and tenth segments like prothorax. Wing pads, legs and antennae hyaline, with a yellowish tinge. The first pair of wing pads extend to the beginning of the third abdominal segment, and the second pair to the beginning of the fourth. Both pairs extend more or less ventro-caudad; the two pairs are distinct. The antennae

extend backwards over the head and prothrorax but are free. The two basal segments are closely applied to the head, while the rest of the antenna curves upwards. The antenna resembles that of the adult in form."

Pupa. The pupa resembles the prepupa closely except that the wing pads extend to about the seventh abdominal segment, and the antennae are flat down over the head and pronotum, extending to near the hind margin of the latter.

Adult.- For a description of the female see Hinds' Monograph, pages 127 to 129, and for the male, Uzel's Monograph, page 75.

LIFE HISTORY AND HABITS.

Oviposition.- The female lays her eggs in the leaf tissue, very much as the onion thrips female does. The act of oviposition was observed twice, but in neither case was the whole operation seen in detail. The female bends the abdomen, bringing the tip forward, curved down near the leaf. She then moves it backwards, with the tip on the leaf surface and repeats the process until the point of the ovipositor catches in the leaf, when the boring and subsequent egg laying takes place. On one occasion a female was seen with her ovipositor inserted in the leaf as far as its base.

Larva.- In both stages the larva is a long bodied, slender thrips with long legs and antennae. It lives in flowers, in grass and on the leaves of plants, wherever it can find thrips to prey upon. It runs actively, searching for food, and apparently depending upon stumbling acroes its prey. It is often found hiding in the sheath of an onion leaf, or on the underside of a leaf that is bent over. When it issues from the egg the larva is small, and white in color; the legs and antennae appear to be too large for the slender body; it runs rapidly, however, and increases in size very soon after beginning to feed.

An apparently newly issued larva was once found running around actively on an onion plant. Upon encountering a half grown Thrips tabaci larva of about its own size, it seized the larva and at once began feeding upon

it. The tabaci larva struggled for a very short time and then became perfectly quiet. The larva once carried its victim for a short distance upon being disturbed. The abdomen could be seen stretching and expanding as the intestine filled with juices from the body of the tabaci larva. After about ten minutes the abdomen began to turn orange yellow, while at first it had been translucent white. The tabaci larva was completely sucked out in about twenty minutes. After leaving the first victim the larva encountered several large tabaci larvae, but it did not attack them.

On another occasion an adult of Thrips tabaci in one of my rearing vials was destroyed by a newly issued Aeolothrips larva. The latter evidently issued from the bit of onion leaf placed in the vial as food for the tabaci adult and finding only the adult, seized it and completely sucked out its juices. When found the larva showed the characteristic yellow color, attained only after feeding; the day before there was only the adult Thrips tabaci in the vial.

Larval molt.- A molt occurs about four days after birth. It was observed in eight cases, three of which were larvae that were later reared to adults, mounted, and determined. The average duration of the two larval stages in seven cases was: first stage four days; second stage eight days; total larval life twelve days.

Larvae of the second stage can be readily distinguished from those of the first stage by (1) the presence of four strong spines on the dorsal side of the ninth abdominal

segment and (2) the lack of the extremely long spines on the tenth segment of the abdomen.

When the Aeolothrips larva reaches maturity it is large, with the abdomen plump, smooth and heavy, and the color, especially that of the abdomen, a deep orange yellow, varying to light orange. It stops feeding at this time and seeks out a place in which to transform to the pupal stage.

Method of Seizing the Prey.- When a larva comes close to a larva or adult of the onion thrips it darts forth suddenly and attacks the prey. It apparently makes no difference where it happens to take hold of its prey, as a young larva was once seen to seize an active adult onion thrips by the antenna and begin to suck its juices. Usually the victim is attacked in the abdomen or on the thorax. It was repeatedly noticed that after the Aeolothrips larva had had a hold on its victim for a few seconds there was no further struggle. The opposite was found to be true in the case of thrips attacked by nymphs or adults of Triphleps and Reduviolus, in which case the victims would keep on struggling and kicking for a considerable time. The possibility of a poison secreted and used by the Aeolothrips larvae to stun their prey was the only supposition that suggested itself in explanation of these facts.

The larva does not use its fore legs to grasp its prey, but at times it was seem to hold the fore legs on the thrips on which it was feeding. As the maxillary palpi

are prominent and strong, they may possibly be used in grasping the prey. No definite observations were, however, made on this point. The idea that the maxillary palpi might be prehensile was suggested by their size and position and the suggestive way in which they are bent inwards towards the tip of the mouth cone. Reuter said in this connection: "Aeolothrips fasciata also shows, in the structure of its mouth parts, a characteristic that is probably connected with a carnivorous life. Bohls expressly remarks: 'Aeolothrips is distinguished from all other thrips by its strongly developed maxillary palpus which is almost as long as the whole mouth cone.' The unusually stout form of the maxillary palpus does indeed seem to fit it, together with its somewhat geniculate outward-bent condition, to be of assistance in holding the victim that has been seized."

In all probability the heavy, chitinous unpaired mouth bristle, or mandible, is used in grasping and holding the prey in connection with the maxillary palpi. It was frequently noticed that the larvae dragged their prey for a short distance, holding it entirely in the mouth cone.

The Process of Feeding.- The method of feeding is probably very similar to that described below for leaf feeding species of thrips. After the larva once seizes its prey there is no noticeable movement on its part during feeding, except that slight movements of the alimentary canal can be plainly seen through the transparent body wall. The intestine of the larva can be seen filling with the juices

of the prey, while the latter diminishes in bulk and finally collapses completely. Often the larva would feed at one end of the body of its victim for a time and then move off to another part. Ordinarily the sucking process continues until nothing but the collapsed skin of the larva, or adult, is left.

The time taken by the Aeolothrips larva to completely destroy its prey was recorded twice. One larva sucked out a tabaci larva completely in an hour and twenty minutes; another removed the juices from an adult onion thrips in forty minutes.

The Number of Thrips Destroyed.- An attempt was made to determine the number of thrips larvae and adults that a single Aeolothrips larva could destroy. To this end a careful count was made of the thrips placed in the vials with the Aeolothrips larvae that were being reared, and of the number of thrips left when the vials were examined again. The results obtained in this way are, however, not very conclusive. The fact that say half the number of larvae placed in a vial with an Aeolothrips larva were dead or could not be found on the following day did not necessarily mean that they were all destroyed by the Aeolothrips, since some might die naturally while others hid away in the cotton or in some crevice of the onion leaf.

As far as the total number destroyed is concerned, one larva destroyed in all 16 thrips, another 20, and still another 24 thrips. The daily average varied from 1.33 thrips destroyed to 5 thrips destroyed. The average of

the average daily consumption of twelve Aeolothrips larvae was found to be 3.39 thrips destroyed per day.

The average length of the larval stage was found to be about 12½ days. It seems safe to estimate that, under normal conditions, a larva of Aeolothrips will probably destroy between thirty and forty thrips.

Reuter found that, on the average, a nearly full grown larva of Aeolothrips fasciatus would suck out from 7 to 8 larvae and adults of Thrips tabaci in a day.

The Species Preyed Upon.- The larvae of Aeolothrips fasciatus were commonly observed feeding upon larvae (prepupae and pupae in vials) and adults of Thrips tabaci. They were often taken on grass with Euthrips obscurus Müller and once at least a larva was seen feeding on a thrips larva that probably belonged to this species.

Reuter found the larvae on grains with larvae of Physopus tenuicornis Uzel and Limothrips denticornis Haliday. and supposed that they were feeding on these two species. In view of the fact that the adults of the species are taken on many different plants in widely separated localities, it seems probable that the larvae of Aeolothrips feed upon many species of Thysanoptera, at least of the Terebrantia.

Cannibalism.- Reuter came to the conclusion that the larvae of Aeolothrips fasciatus were not cannibalistic. I have on several occasions seen Aeolothrips larvae feeding upon other larvae of their own species in my breeding vials. Once a larva was seen fedding upon another a good

deal larger than itself. This cannibalism appeared not only when the vial contained only Aeolothrips larvae, but also when larvae and adults of Thrips tabaci were present. Aeolothrips larvae were occasionally seen to feed upon dead thrips, but it seemed as though live prey had greater attraction for them.

Length of Larval Life.- In five ~~live~~ larvae taken in the field, probably early in the first stage, reared to adults and determined as Aeolothrips fasciatus, the two larval stages varied from 10 to 14 days, the average being 12.4 days. In the case of eight larvae reared, but not determined, the two larval stages together lasted for from 11 to 18 days, the average being 13.6. Combining the results obtained from the five determined and eight undetermined larvae we find that the larval stages together varied from 10 to 18 days and that the average for thirteen individuals was 13.15 days. For convenience the larval stage was considered as ending when the larva entered the soil to spin its cocoon, although the actual molt between the larval and prepupal stages probably occurred from one to two days after that time.

Place of Pupation.- When a small amount of loose muck soil was placed in the bottom of the vials in which the Aeolothrips larvae were reared, the mature larvae invariably entered the soil for pupation. In the field then the normal place of pupation is probably in the loose

soil at the base of the onion plants, perhaps an inch below the surface.

The larva works its way into the soil by scraping loose particles away with its legs and forcing its body into the cavity made in this way. In the vials they frequently excavated their pupating cells next to the side of the vial, so that the cocoon spinning process could be readily observed. After it is in the soil the larva excavates a cell by throwing the abdomen more or less violently from side to side or up and down. The main part of the abdomen of the larva is plump and well filled out, but the two apical segments are much more slender than the eighth together forming a rather sharply tapering cone that is lighter in color than the rest of the abdomen.

The Cocoon.- The small delicate cocoon in which the two pupal stages of Aeolothrips are passed, is made out of thin yellowish silk. The silk is spun from the tip of the tenth abdominal segment, in all probability from the anus. During the process of spinning the abdomen is moved slowly from side to side and up and down, and besides this motion, the two apical segments have an independent motion, moving in various directions, and also at times back and forth along the long axis of the body. The tip of the tenth segment is applied to whatever surface it happens to touch, and then moved off and again applied to another spot. Evidently the silken thread is fastened at these various points

by some sticky substance. While it is spinning the silken cocoon around itself the larva often turns completely around, spinning first at one end of the cocoon and then again at the other end.

The completed cocoon is a delicate, partly transparent cell of a dirty yellow color. The larva can be seen in the cocoon, but not sufficiently well to enable the observer to determine whether or not it had transformed to a prepupa. The cocoon is about two millimeters long and perhaps half a millimeter wide.

Usually the cocoons were spun in the loose soil placed in the breeding vials. Sometimes the larva would spin its cocoon between the cotton stopper and the vial, and some were also spun in the portion of the onion leaf upon which the prey was placed.

The Prepupa and Pupa.- In the case of most of the individuals that were reared to the adult stage from larvae, the pupal stages were passed in the cocoon described above. In a few cases the larva was disturbed while spinning its cocoon, or removed from a partly completed cocoon, and then it molted and transformed to the prepupa and later to the pupa in an exposed place, e.g., on the bottom of the vial. In transforming from the larva to the adult, Aeolothrips passes through external changes that are very much like those that Thrips tabaci undergoes in its development. The prepupa resembles the adult more nearly than it does

the larva. The antennae extend dorsad and then curve forward again somewhat. The wing pads extend to between the third and fourth abdominal segments. The Pupa resembles the prepupa in general appearance; it is colored a deep orange yellow, and a day or more before transforming to the adult the wing pads and the body begin to darken up gradually until they are dark brown to blackish just before the molt occurs. The antennae of the pupa are laid down flat over the dorsum of the head and extend nearly to the hind margin of the pronotum. The wing pads extend as far as the seventh segment of the abdomen.

The length of the prepupal and pupal stages was satisfactorily determined for only one individual, and was found to be prepupa 6 days, pupa 3 days, total 9 days. Three other individuals passed through these two stages outside of a cocoon because they had been disturbed while spinning it, but in none of these instances were the records satisfactory, because the individuals just barely transformed to adults and then died. The failure of these individuals to transform normally was probably largely if not entirely due to the exposed abnormal conditions under which they pupated. A number of individuals that had entered the soil in their vials, presumably for pupation, during the latter part of August and the beginning of September failed to emerge as adults. The vials were kept through the winter in the hope that the adults might emerge in the spring, but at the end of May none of these individuals had issued.

The total number of days that elapsed between the disappearance of the larva and the emergence of the adult was determined for ten individuals that were mounted up after they had transformed to adults and determined as Aeolothrips fasciatus. This period was found to vary from ten to eighteen days, the average being 13.8 days.

In addition to actual pupation this period included the time spent by the larva in finding a suitable place in which to pupate and in spinning its cocoon. This would explain the difference between the figures just given, 13.8 days and the total days spent in pupation, 9 days, recorded above.

The Adult.- The newly transformed adult has a greyish black appearance, and is not very active for the first twenty-four hours. After this period has elapsed it takes on a shining black color and becomes very active. These notes are from observations made on the individual from which the pupal stage records were obtained. Normally, when the pupal stages are passed in the cocoon the final molt and transformation takes place in the cocoon, and the adult remains in it for about a day until it attains the normal black color. For this reason the adults that emerged from cocoons always had the normal black color.

The adult of Aeolothrips fasciatus is a conspicuous large form that attracts attention by the contrast between the black color of its body and legs and wings (in part) and the three white bands across the wings. It is very

active, running rapidly when disturbed. Normally the adults are found in flowers and on onions or in grass, resting quietly and apparently feeding on the plant tissues. They move slowly and then again very rapidly, especially when they are distrubed. The adults were never observed to spring, but they do occasionally take flight. Their first impulse and normal action is, however, when disturbed to run rapidly down towards the base of the onion plants or in between the leaves and hide. They would frequently run off into the loose soil, thus protecting themselves from the collector and perhaps likewise from their enemies.

Considerable difficulty was experienced in keeping adults alive in vials. In no case was an adult kept alive for more than ten days. This was true both of adults reared from larvae and of those taken in the field. The adults were placed in vials containing a small piece of a green onion leaf, under conditions similar to those under which the adults of Thrips tabaci were kept alive for 60 days. The adults reared from larvae lived from three to ten days, but none of them seemed to be as active or as plump and heavy as those taken in the field.

At least ten or twelve attempts were made to determine definitely whether or not the Aeolothrips preyed upon Thrips tabaci larvae or adults. The adults of Aeolothrips were confined in vials with a bit of an onion leaf on which there had been placed a definite number of larvae or adults of Thrips tabaci. The latter were then carefully counted again on the following day. In some cases one or

two of the onion thrips disappeared, but it was doubtful whether the Aeolothrips had destroyed them. Only in one instance was a female Aeolothrips in a vial seen to stand over a dead Thrips tabaci larva with its mouth cone closely applied to it. Soon, however, she moved off. In the field the adults were frequently seen standing motionless on an onion leaf, with the tip of their mouth cone closely applied to the surface of the leaf.

From the observations of the past season it seems safe to say that the adult of Aeolothrips fasciatus is not predaceous upon other thrips and that it feeds upon the leaves of the onion plants, sucking out the juices from the tissues. Ordinarily the adults were at least as abundant on the onions as the larvae and the former were much more conspicuous. Again the larvae were frequently found feeding upon larvae or adults of Thrips tabaci. With these facts in view, it seems logical to suppose that, if the adults were predaceous, they would, in some cases at least, have been found feeding upon the onion thrips.

Male.- The male of Aeolothrips fasciatus is much smaller than the female and is distinguished by its lighter color, the broadly rounded tip of the abdomen and the conspicuous orange colored testes. The males are scarce, and, as far as I can learn, have not yet been reported from the United States. At Elmira, N.Y., on July 1, 1912, two males were taken on onion plants in company with many females and Thrips tabaci larvae and adults. At least a hundred adults

of Aeolothrips were collected in various localities, but no other males have been found among them. It is not unlikely that the species is, for one or more generations at least, parthenogenetic. This could, however, be definitely determined only by actually rearing larvae from eggs that had been laid by unfertilized females.

The Copulation of this species was described by Dr. Pietro Buffa in 1907. A pair collected in copula by him remained in their relative positions in the alcohol, so that he could make a drawing illustrating the process. The following is a free translation of his description of the method of copulation:

"The male allows himself to be actually (completely) carried by the female, who does not, on that account, diminish her ordinary speed in the least. The male places himself with his thorax and head on top of the female, and, bedding the abdomen upwards, places the ventral side of the last two segments of the abdomen in contact with the ventral part of the eighth abdominal segment of the female. The ninth abdominal segment of the male holds, as if with pincers, the ventral side of the female, between the eighth and ninth segments, and thus facilitates the entrance of the penis, which, on account of the position of the body of the male, comes to be bent forwards. The penis penetrates quite deeply into the body of the female; by clearing the specimens one can see that it reaches nearly to the dorsum of the eighth abdominal segment(of the female.)"

REARING EXPERIMENTS.

Aeolothrips fasciatus were reared in cotton stoppered vials used for rearing Thrips tabaci. Usually several larvae or adults of the onion thrips were placed in the vial upon a piece of onion leaf. The thrips intended as food for the Aeolothrips were counted every day, or every other day, additional ones being added from time to time. When the Aeolothrips larva approached maturity some loose muck soil was usually placed in the vial. In this way the conditions under which Aeolothrips was reared resembled the natural conditions quite closely. Adults of Aeolothrips fasciatus were likewise confined in vials, in many cases with Thrips tabaci larvae or adults. Several attempts were made to determine the length of the egg stage by placing adults upon onion plants covered with glass chimneys. A female was once seen ovipositing in one of these plants, but no larvae were obtained.

In all twenty-nine larvae of Aeolothrips were confined in vials for a shorter or longer time with a view to rearing them to adults. The longest period that an individual was confined, counting all its stages, was thirty-seven days. Of the twenty-nine individuals, fifteen did not complete the pupal stage. Eleven of the remaining fourteen were mounted up and determined.

LIFE CYCLE.

One larva at least was taken in the field shortly

after it had issued from the egg. The records obtained from this individual were: larval stages 14 days, pupal stages 10 days, length of life of adult, 8 days.

In thirteen individuals the sum of the larval stages was found to vary from 10 to 18 days, the average being 13.15 days.

In ten individuals the pupal stages together varied from 10 to 18 days, the average being 13.8 days.

The time that elapsed from the issuing of the larva to the emergence of the adult was approximately 27 days.

NUMBER OF GENERATIONS.

Adults of Aeolothrips fasciatus were collected last year from May 10th to about September 15th. Assuming the length of the egg stage as probably 10 days, the life cycle from egg to adult would be 37 days. Probably, then, there are about four generations during the summer. I was unable, however, to distinguish definite broods. During July, August and September larvae of both stages as well as adults were commonly found together.

ECONOMIC IMPORTANCE.

Various writers have reported that Aeolothrips fasciatus was common on wheat, buckwheat, clover and other flowering plants. Thaxter '90 was the only author who thought that the species was injurious, believing, as he did, that it caused a rust of oats in Connecticut.

Packard '72 found the larva in company with thrips on onions and described it as the wingless male of Limothrips tritici. Gillette '93 found it common on onions with Thrips striatus?. In 1902 Reuter wrote that Aeolothrips fasciatus larvae preyed exclusively upon Thrips communis (= Thrips tabaci.). It is interesting to note that both Packard and Gillette found Aeolothrips fasciatus in company with thrips on onions, but no one suspected what the relation was between the two species until Reuter found that the Aeolothrips larvae preyed upon Thrips communis. Wherever Thrips tabaci was found in considerable numbers upon onions during the summer of 1912 Aeolothrips adults were also present in appreciable numbers. Usually Aeolothrips larvae could also be found without much difficulty.

Evidently Aeolothrips fasciatus is one of the most important enemies of Thrips tabaci. It undoubtedly exerts an appreciable influence upon the onion thrips by reducing its numbers and thus in a measure checking its increase.

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Aeolothrips fasciata. Description of copulation.

1907b Schtscherbakow, Th. S.-- Beitrag zur Kenntnis der Thysanopteren Mittelrusslands. Zool. Auz. vol. 31, pp. 912 914.

Aeolothrips fasciatus.

1908 Karny, Heinrich-- Die orthopterenfauna des Küstengebietes von Osterreich-Ungarn. Berl. Ent. Zeitschr. Vol. 52, p. 45.

Aeolothrips fasciata.

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Aeolothrips fasciatus in 22 flowers.

1910 Karny, Heinrich-- Neue Thysanopteren der Wiener Gegend. Mitt. Naturw. Ver. Univ. Wien. vol. 8, pp. 44-45, pl. V, fig. 8.

Aeolothrips fasciata forma aptera nov.

1911 Moulton, Dudley-- Synopsis, catalogue and bibliography of North American Thysanoptera, with descriptions of new species. Tech. Ser. 21, U. S. Dep. Agr. Bur. Ent., p. 22.

Aeolothrips fasciatus. Food plants.

1912 Karny, Heinrich-- Ueber einige afrikanische Thysanopteren. Ent. Zeitschr. (Fauna exotica). Frankfurt a. M., Jahrg 2, No. 5.

Aeolothrips fasciatus in Tunis and "Klein Namaland."

* 1912 Stráník, F.--(A contribution to the knowledge of the phytopathologic importance of grain thrips.) Deutsche Landw. Presse. vol 39, (12) no. 67, p. 771, figs. 6.

Aeolothrips fasciata on barley.

I have not seen the references marked with an asterisk (*).

EUTHRIPS OBSCURUS MÜLLER.

(= Anaphothrips striatus Osborn)

The Grass Thrips.

During June and July in 1912 this species, commonly known as the grass thrips, was found on onions in several localities. It was found either alone or with Thrips tabaci.

At Williamson, N.Y., (Wayne County) on June 15th the only thrips that I found on onion plants in the field were adults of this species. Later larvae issued from some of these plants that had been brought to Ithaca, showing that the species bred upon onions.

The grass thrips was present on onions at Canastota in June and July, but in August it could be found on onions only with difficulty. At Canastota, in June, Euthrips obscurus was quite commonly found in one field on the grass along the ditch banks and between the onions. As the grass along the ditches had been cut a short time before it is probable that the species had left the grass to go to the onions. The adults seemed to be more abundant on the June grass growing between the rows of onions than on the onions themselves.

It is interesting to note that several writers have referred to the thrips on onions as Thrips striata Osborn (=Euthrips obscurus Müller). These references have been included under Thrips tabaci because it is probable that the authors were referring to Thrips tabaci. In view of the above observations it seems possible that these early writers

found and confused the two species on onions.

The grass thrips was first mentioned in America by Professor Comstock in 1875 as Limothrips poaphagus. (Syllabus of Course of Lectures 1875, p. 120; Introduction to Entomology 1888, p. 127; Manual for the Study of Insects 1895, p. 120.) Osborn described it in 1883 as Thrips striata (Can. Ent. vol. 15, p. 155). Fletcher (20th Rep. Ent. Soc. Ont. pp. 2, 22) referred to the species under the name Phloeothrips striata in 1889. Hinds, in 1900, (37th Ann. Rep. Mass. Agr. College) wrote on the species and placed it in the genus Anaphothrips Uzel. In 1910 Bagnall stated (Ann. Soc. Ent. Belg. vol. 54, pp. 461-462) that Anaphothrips striatus Osborn was a synonym of Anaphothrips obscurus Müller. (Thrips obscura, Muller, Zoologiae danicae Prodromus, 1776, p. 96.) In 1912 Karny (Zool. Annalen Wurzburg, 1912, pp. 333-334) placed the species in the genus Euthrips Targioni-Tozzetti,so that it must now be known as Euthrips obscurus Müller.

The injury done by this species to timothy and June grass was first mentioned by Professor Comstock in 1875. Many writers have since discussed its importance as a pest of grasses. Some considered it as the cause of "silver top" of hay, while others thought that it was harmless. The concensus of opinion to-day seems to be that Euthrips obscurus is responsible, in part at least, for "silver top" of hay. Dr. Hinds studied the life history of the species in Massachusetts. He described the adult and the immature stages in his Momograph (pp. 161-166), and gave a summary of its

life history and economic importance. Cary (Bull 83, Maine Agr. Exp. Sta. 1902) wrote on the anatomy, histology, development and habits of the species and figured a wingless male that evidently belonged to an entirely different species. Shull (Ent. News vol. 20, p. 224) described the male from Michigan in 1909. Hinds bred the species parthenogenetically through several generations.

About ten individuals of this species were reared from young larvae to adults upon onion leaves under conditions similar to those that obtained in my rearing experiments on Thrips tabaci. The results were as follows:-

Larval stages 12 to 28 days, average of 6 individuals 20.8 days.

Prepupal stage 1 to 4 days, average of 4 individuals 2.75 days.

Pupal stage, 4.0 days.

Prepupal plus pupal stage 6 to 8 days, average of 4 individuals 6.7 days.

Length of life of adult, maximum 65 days.

Euthrips obscurus can easily be distinguished from Thrips tabaci in the field. The adults are uniformly brownish yellow in color, being much lighter in color than the dark forms of Thrips tabaci. The sixth segment of the antenna is darker than the preceding ones, giving the antenna the appearance of being tipped with brown. They do not jump and are generally much less active, moving comparatively slowly when disturbed. The adults of Thrips tabaci,on the other

hand, are, on the onions at least, much darker in color than Euthrips obscurus, having the abdomen brown to dark brown. They are active, run rapidly, or jump, especially when disturbed.

Although the grass thrips is of considerable economic importance as a pest of timothy and other grasses, it was not present on onions in sufficient numbers last year to do any appreciable damage.

CARNIVOROUS THYSANOPTERA.

The earliest reference to carnivorous thrips that I have found is that of Dr. B. D. Walsh. He found a species of thrips in the galls of Phylloxera caryaefoliae and concluded (Proc. Ent. Soc. Phila. vol. 1, 1862, p. 310) that it was feeding upon the gall producing aphids. In 1864 he expressed the opinion (Proc. Ent. Soc. Phila. vol. 3, pp. 609, 611-612.) that "they (thrips) are generally, if not universally insectivorous." The following year he expressed the same opinion (Pract. Entom. vol. 1, p. 21) and in 1867 he stated " I have since found thrips preying upon the gall-making larvae of more than twenty different galls. ... so that there is now no manner of doubt in my mind that thrips is a true cannibal insect." (Pract. Ent. vol. 2, p. 50.) C. V. Riley, in 1870 (2d Mo. Rep. p. 6; Amer. Entom. vol. 2, pp. 134,135) found a minute yellow thrips destroying the eggs of the plum curculio. In 1874 he stated that Thrips phylloxerae of his MS. was the most efficient natural enemy of the

Phylloxera (6th Mo. Rep. pp. 55-51, fig. 9). Pergande (Psyche vol. 3, p. 381, 1882) found a species of Thrips feeding upon adults and young of Tetranychus telarius the common red spider and later described it as Thrips 6-maculata (Trans. St. Louis Acad. vol. 5, 1894, p. 542). Hinds, in his Monograph (1902) redescribed this species under the name Scolothrips 6-maculatus Pergande. Jordan, in 1888 (Anatomie und Biologie der Physapoden, Zeitschr. wiss. Zool. vol. 47, p. 602) mentioned the observations of Walsh. He found thrips among grape vine root-lice, but said they had nothing to do with the lice. Professor Herbert Osborn, in 1888, (Ins. Life vol. 1, pp. 137-142) reviewed and quoted what had been written about the food habits of the Thripidae and gave his own observations. He concluded that thrips as a group are normally herbivorous, only two species being carnivorous, the one destroying Phylloxera and the other Telarius. In 1891 Bohls (Die Mundwerkzuege der Physopoden. Inaug-Dissert. Göttingen, p. 35, note) observed the larvae of Phloeothrips aculeata Fabr. (= Haplothrips aculeatus Fabr.) feeding upon dead flies and injured individuals of their own species. Fernald found that a species of Phloeothrips destroyed the eggs of the gypsy moth (Bull. 19 Mass. Agr. Exp. Sta. 1892, p. 116). Thrips trifasciatus Ashmead (Ins Life vol. 7, 1894, p. 27) fed upon the cotton white fly (Aleurodes gossypii). In his Monograph Dr. Hinds stated (p. 118) that Anaphothrips striatus Osborn

(= Euthrips obscurus Müller) occasionally became cannibalistic, feeding upon members of its own species when confined without food. In connection with the observations of Walsh and Riley upon thrips destroying the Phylloxera he pointed out that the thrips may have entered the galls merely for protection or pupation. He thought that further observations were necessary before the conclusion that thrips prey upon gall makers could be accepted. In 1902 Reuter (Aeolothrips fasciata (L.), eine carnivore Thysanoptere, Meddel Soc. Fauna Flor. Fennica vol. 28, pp. 75-83) published his observations on the habits of the larva of Aeolothrips fasciatus, thereby adding another species to the list of truly carnivorous Thysanoptera. He found that larvae of this species fed exclusively upon Thrips tabaci larvae and adults. He mentioned the observations of Walsh, Riley, Pergande and Bohls, and accepted the following three species as carnivorous:- (1) the species of thrips of Walsh and Riley feeding upon Phylloxera (probably carnivorous), (2) Pergande's species feeding upon Tetranychus and (3) Anthothrips aculeata Fabr. observed by Bohls. He stated that the last mentioned species was carnivorous only under certain conditions, since it had been injurious to grains in various countries. Dr. H. J. Franklin (Ent. News vol. 20, 1909, p. 230) stated that Aleurodothrips fasciapennis Franklin had been observed since 1906 feeding upon the larvae, pupae and eggs of the citrus white fly (Aleyrodes citri) in Florida by Morrill and Back (Bull 102, U. S. Dep. Agr. Bur. Ent.

1912, p. 9 and Ent. News vol. 23, 1912, pp. 73-74.)

I have made the following observations on carnivorous Thysanoptera.

In 1911 I saw an adult of Scolothrips 6-maculatus feeding upon red spiders on the leaves of a cottonwood tree at Lindsay, California. Adults, larvae and pupae were present on the leaves, under the fine network of silk stretched between the veins of the leaf by the mites. In all probability the larvae also fed upon the mites, although I did not see them doing so. The same species was taken again in 1912 on horse chestnut at Goshen, N.Y., and on elm leaves at Chester, N.Y. Red spiders were present on the leaves in each case, but the thrips were not seen preying upon them.

While I was studying the life history of the onion thrips I found the larvae of Aeolothrips fasciatus preying upon the larvae and adults of Thrips tabaci. Aeolothrips albocinctus Haliday was, in the case of one reared individual, also found to be predaceous upon Thrips tabaci larvae. An Aeolothrips larva, about half grown, that I took to be Aeolothrips fasciatus, fed upon Thrips tabaci larvae that were placed in the vial in which it was confined. When the larva finally transformed to an adult it proved to be a wingless male of Aeolothrips albocinctus Haliday. Adults of this species were also collected as follows:- winged and wingless females on corn leaves with Euthrips obscurus at Canastota; a winged female on onions with Thrips tabaci at Elmira; and a wingless female on onions with Thrips tabaci at Chester, N.Y. All

these specimens have been sent to Mr. Hood for determination, but they have not yet been returned. Considering that one individual of this species fed upon Thrips tabaci larvae in its larval stage, and that adults of the species were collected in several places with Aeolothrips fasciatus, it seems probable that Aeolothrips albocinctus is normally predaceous in its larval stage.

Aeolothrips bicolor Hinds was collected with Aeolothrips fasciatus on onions infested with thrips and adjoining grass at Chester and Florida in Orange County. From the similarity in habits and appearance between these two species and the fact that they occurred together it seems probable that the larvae of Aeolothrips bicolor will also be found to prey upon Thrips tabaci.

At Florida, N.Y., in August 1912, I found a conspicuous black Phloeothripid running around actively on the leaves of a willow tree. Upon closer examination I found that there were many red spiders on the leaves. Both larvae and adults of this species were confined in a vial in which a willow leaf with red spiders upon it had been placed. Under these conditions both larvae and adults fed upon the red spiders. When Thrips tabaci were placed in the vial the larvae and adults fed upon them also. The females laid their eggs upon the cotton stopper of the vial; the larvae that issued from these eggs were fed upon Thrips tabaci larvae. One of these developed into an adult. The Phloeothripid larvae and adults were not seen to feed upon the

willow or onion leaves. The species agrees quite closely with the description given by Hinds for Haplothrips (=Anthothrips Uzel) verbasci Osborn except in the comparative length of the tube and head. Specimens have been sent to Mr. Hood. Until he determines them it may be provisionally accepted that the species is Haplothrips verbasci Osborn. From the observations recorded it appears that this species is probably normally predaceous upon red spiders both as a larva and as an adult.

It is interesting to notice how the species of Thysanoptera that are known to be carnivorous are distributed among the suborders and families.

Suborder Terebrantia
  Family Aeolothripidae
    Aeolothrips fasciatus Linnaeus larva
    Aeolothrips albocinctus (?) Haliday larva
  Family Thripidae
    Scolothrips 6-maculatus adult and larva (?)
Suborder Tubulifera
  Family Phloeothripidae
    Haplothrips aculeatus Fabr. in part carnivorous
    Haplothrips verbasci Osborn (?) adult and larva
    Aleurodothrips fasciapennis Franklin adult

The life history and habits of only one species of the family Aeolothripidae (Aeolothrips fasciatus) have been worked out as far as I know. In view of the fact that Aeolothrips albocinctus Haliday is probably also predaceous, it seems possible that the members of this family may be found to be generally carnivorous. To the Thripidae belong many of the best known and most destructive herbivorous species of thrips, e.g., the pear thrips, onion thrips and green house thrips, but at least one member of the fam-

ily, Scolothrips 6-maculatus is evidently normally carnivorous. To the Phloeothripidae belong some injurious forms that are normally herbivorous, e.g., the olive Phloeothrips in Italy. The three species mentioned above are, in part at least, carnivorous.

Since the majority of the thrips, whose habits are known, are herbivorous, Osborn and Reuter have concluded that the Thysanoptera were originally and normally herbivorous, and that the carnivorous habit has been secondarily developed. As a general principle, the more generalized members of a group would be more likely to retain the habits of the ancestor of the group. The Aeolothripidae have been considered as the most generalized members of the order. It may be significant that the only species (Aeolothrips fasciatus) whose life history has been worked out is normally, if not exclusively, carnivorous, and that one other species (Aeolothrips albocinctus) is probably also carnivorous. On the other hand there are more carnivorous forms known in the Phloeothripidae than in the Thripidae, while the Tubilifera are generally considered as being more highly specialized than the Terebrantia.

It seems that further observations will have to be made on the food habits of the members of the order before generalizations can safely be made as to whether or not the carnivorous habit has been secondarily acquired.

Dr. Walsh very evidently overestimated the case when he said that "thrips are generally, if not universally, insect-

ivorous." But it may be that further observations on the feeding habits of Thysanoptera may tend to show that his generalization was nearer to the truth than has generally been supposed.

THE MOUTH PARTS OF THYSANOPTERA.

Description.- The mouth parts of the Thysanoptera are fitted for sucking. In some respects, such as the form of the outer lobes of the maxillae and the presence of maxillary and labial palpi, the mouth parts resemble those of the biting type.

Externally the mouth parts consist of a broad cone-shaped beak that extends either downwards or backwards and downwards from the hind margin of the head on the under side. The cone usually appears to be attached to the underside of the prothorax and extends backwards between the fore legs. It is movable, articulating with the head and prothorax by membrane. The cone is very prominent and it can be extended almost at right angles to the main axis of the body in the Aeolothripidae. In the family Thripidae the cone is more or less prominent. The Tubilifera usually have a broad, flat cone that extends backwards under the prothorax and that is therefore often inconspicuous.

The walls of the mouth cone consist of the labrum, below (in front), the two maxillae at the sides, and the labium above (behind). The triangular labrum is asymmetrical, especially so in the Terebrantia, extending further towards

the eye on the right side than on the left; it is narrowed towards the tip of the cone, being bluntly rounded or drawn out to a spine-like point in certain Tubilifera.

The maxillae are broad and flat, tapering to a narrow point at the tip of the mouth cone. They bear palpi at about the middle of their length. The maxillary palpi may be composed of from one (Urothrips Bagnall) to eight segments (Stomatothrips Hood), but they usually consist of either two or three segments. The maxillae form the side walls of the mouth cone and are connected to the labrum and labium by membranes.

The labium forms the posterior (upper) wall of the mouth cone. It may be either broadly rounded at the tip or drawn out to a narrow point. At the apical end it bears the minute labial palpi that may be composed of one (Urothrips Bagnall), two, four or five (Stomatothrips Hood) segments.

The small round mouth opening is at the tip of the cone. The edges of the opening are more or less soft, but it may also be surrounded by certain short spines and chitinized parts of the maxillae and labrum.

Within the mouth cone there lie the three mouth bristles or stylets that can be protruded through the mouth opening. Two of these are paired and longer and more slender than the third unpaired stylet that lies in the left side of the cone.

The unpaired mouth bristle is short and comparatively stout; ~~attached by~~ is attached by muscles to its broad flat base to the wall of the head. It lies on the left side of the head, and there is no

trace of a corresponding organ on the right hand side. Garman, Hinds and Buffa have interpreted this organ as one of the mandibles. Jordan considered it as the epipharynx. Bohls and Uzel described it as the "unpaired mouth bristle" and finally Börner said that it was the inner lobe of the left maxilla.

The long slender paired bristles are composed of two parts, a short basal piece, and a longer distal portion. The basal part acts as a lever, being movably joined to the distal part. In the Terebrantia these bristles are joined to the basal part of the maxillae, while they attach to the wall of the head in the Tubilifera. They are very long in the latter suborder, being bent back to near the anterior margin of the head when not protruded. Garman, Hinds and Buffa considered these stylets as the inner lobes of the maxillae, while Jordan, Bohls and Uzel interpreted them as the mandibles.

On the inner side of the labium there are certain chitinous structures that have been described as the hypopharynx. The anterior end of the esophagus forms a pumping organ that can be dilated and contracted by the action of muscles.

The Process of Feeding.- Several authors have stated that thrips chew, rasp or scrape the surface of the leaf upon which they feed. There seems to be no foundation for such a view, except that the short spines and chitinous tips of the labrum and maxillae at the tip of the cone may rasp the leaf surface to some extent. On the other hand there

seems to be no doubt that the feeding process consists of piercing the leaf surface and sucking the juices from the underlying cells.

After the mouth opening has been pressed down on the leaf surface the piercing mouth bristles are protruded in order to puncture the epidermis of the leaf. Probably the shorter, stouter, unpaired mouth bristle serves to pierce the tough epidermis. The long slender inner lobes of the maxillary lobes are then inserted into the leaf through the opening made by the unpaired bristle. These probably puncture the underlying cells, thus setting free the cell contents.The maxillary lobes, placed close together, act as a sort of capillary tube through which the juices can be pumped up, through the cone, into the esophagus. The feeding process has been described in detail by Bohls.

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A LIST OF THYSANOPTERA COLLECTED IN NEW YORK 1912 - 1913

In the following list the species have been arranged and numbered according to Moulton's catalogue. (Moulton, Dudley -- Synopsis, catalogue and bibliography of North American Thysanoptera, with descriptions of new species. Technical Series No. 21, U.S.Dep't Agr. Bur.Ent.,1911.) In the case of two species not listed in Moulton's catalogue, a reference has been added to the most available description.

Order Thysanoptera

Suborder Terebrantia

Family Aeolothripidae

(5) Aeolothrips bicolor Hinds

Male; females — Grass; onion

Chester; Florida — August 1; 14.

(7) Aeolothrips fasciatus Linnaeus

Females; two males — Onion;oats; grass; dandelion

Canastota; Elmira; Chester; Florida; Ithaca — May 10 - Sept.15

The larvae prey upon Thrips tabaci Lind.

Aeolothrips albocinctus Haliday

Winged and wingless females; wingless male — Corn; onion

Elmira; Chester; Canastota — July 1 - August 14

Uzel, Heinrich-- Monographie der Ordnung Thysanoptera, Königgrätz, 1895, pp. 75-77, pl.1, fig. 3.

Family Thripidae

(10) Parthenothrips dracaenae Heeger

Females On greenhouse plants

Ithaca January- March

Baliothrips dispar Haliday

Females Grass on ditch banks

Chester April 2, 1913.

Uzel, Heinrich -- Monographie der Ordnung Thysanoptera, Koniggratz, 1895, pp.205-206; pl.7, figs.108,109.

(13) Thrips magnus Moulton

Females, males Dandelion; rhubarb; tobacco; milkweed

Ithaca; Canastota; Elmira June 14- October 8.

(14) Thrips tabaci Lindeman

Females Many flowers and plants

Ithaca; Orange Co.; Canastota; Marion; Elmira Mar.12- Nov.19.

(18) Heliothrips femoralis Reuter

Females Greenhouse cucumbers

Ithaca April; May

(19) Heliothrips haemorrhoidalis Bouché

Females Greenhouse plants

Ithaca January - June

(32) Chirothrips manicatus Haliday

Females Tobacco; milkweed flower

Elmira; Canastota July 2 -6.

(34) Chirothrips obesus Hinds

One female June grass

Canastota July 21, 1912.

(36) Aptinothrips rufus Gmelin

Variety connaticornis Uzel 3

Females Grass siftings

Canastota; Chester; Florida November; March; April.

(37) Scolothrips sexmaculatus Pergande

Males, females With mites on elm and horsechestnut

Goshen; Chester August 1; 14

(43) Physothrips pyri Daniel [=Euthrips Targ.-Tozz.]

Females Pear, apple and plum blossoms

Ithaca. Batavia and E.Bethany (Professor G.W.Herrick). May

(49) Frankliniella nervosa Uzel [= Euthrips Targ.-Tozz.]

Females, long- and short winged Corn; grass; onion

Canastota; Chester; Florida July; August

(54) Frankliniella tritici Fitch [= Euthrips Targ.-Tozz.]

Females; males Various flowers

Ithaca;Canastota;Elmira; OrangeCo.; Williamson May- Septemb.

(56) Euthrips obscurus Müller

[=Anaphothrips striatus Osborn]

Females, long- and short winged Grass; corn; onion

Canastota; Williamson; Orange Co. June - November

Suborder Tubulifera

Family Phloeothripidae

(65) Haplothrips niger Osborn [= Anthothrips Uzel]

Females Daisy

Canastota; Ithaca June ; July

(66) Haplothrips verbasci Osborn [= Anthothrips Uzel]

Females Ivy leaves; with mites on willow

Ithaca; Florida August; October

(87) Hoplothrips magnafemoralis Hinds

[= Acanthothrips Uzel]

Females, males Onion; under bark of sycamore and hickory

Chester; Ithaca; Canastota August; March; April.

(98) Leptothrips aspersus Hinds

Females; males Grape; wild grape

Ithaca May; October

NOTE:- The authority for the changes in generic names in the above list is; Karny, H.-- Revision der von Serville aufgestellten Thysanopteren-genera. Zoologische Annalen, Würzburg, 1912, pp.333-344.

LIST OF FIGURES

Plate I

Figure 1 *Thrips tabaci* egg (×277)

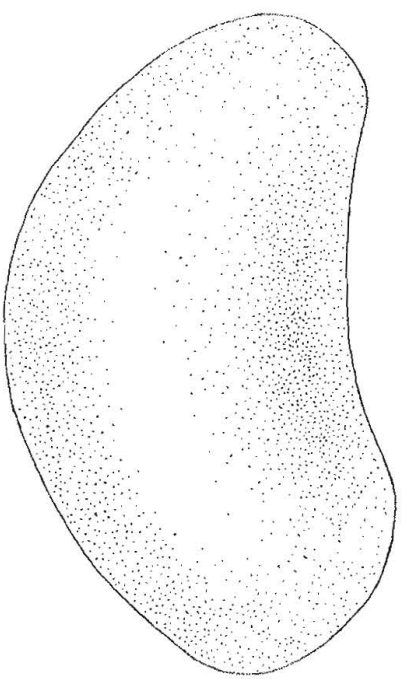
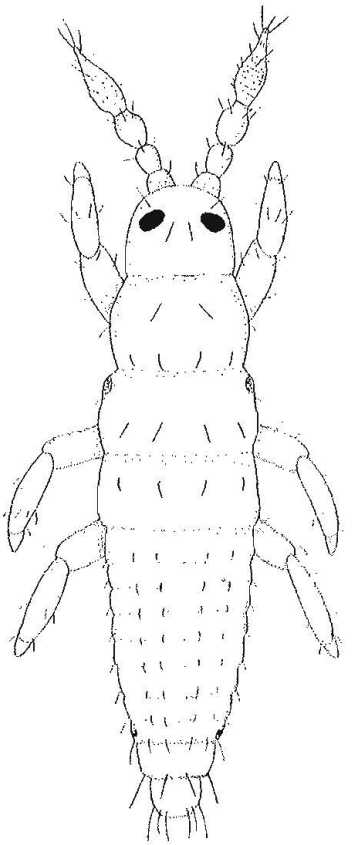


Plate II

Thrips tabaci

Figure 2. First stage larva (Before feeding) (×134)

Figure 3. Second stage larva (Full grown) (×73)



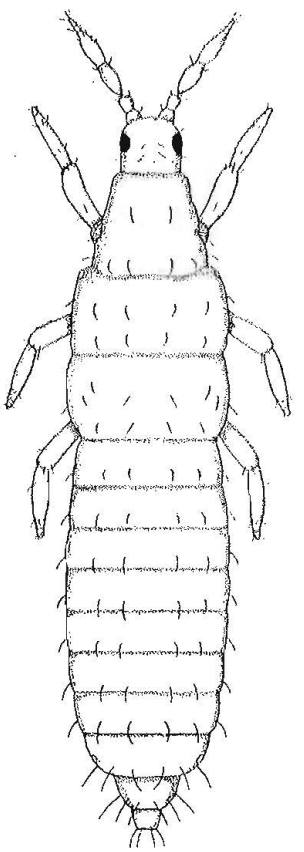
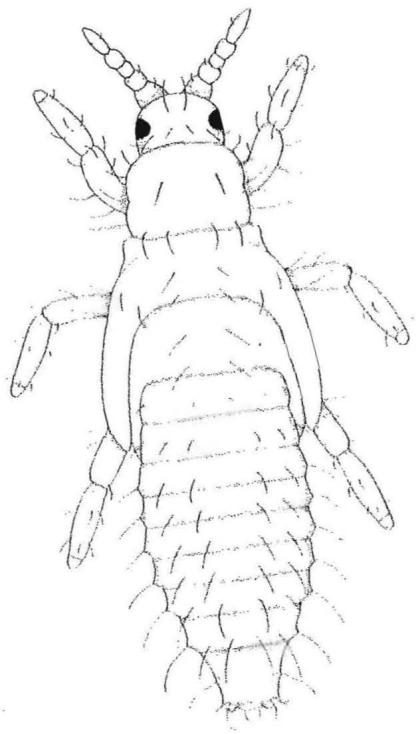


Plate III

Thrips tabaci

Figure 4. Prepupa (×97)

Figure 5. Pupa (×92)



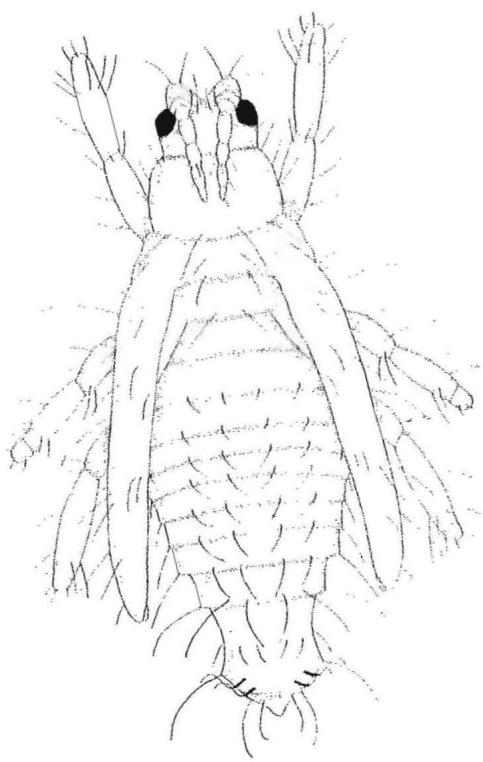


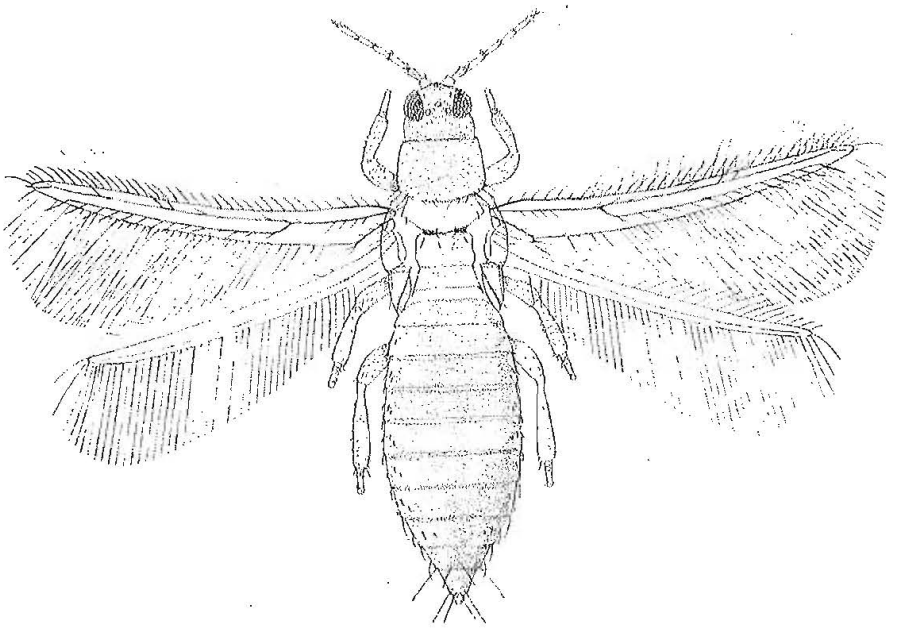
Plate IV

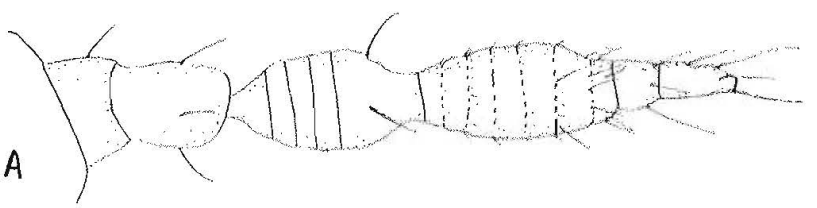
Thrips tabaci

Figure 6. Adult female (×51)

Figure 7. A. Antenna of second stage larva (×385)

B. Antenna of adult female (×200)





B

Plate V.

Figure 8. An onion plant badly injured by thrips.

Figure 9. General view of an onion field. Note the white appearance due to thrips injury

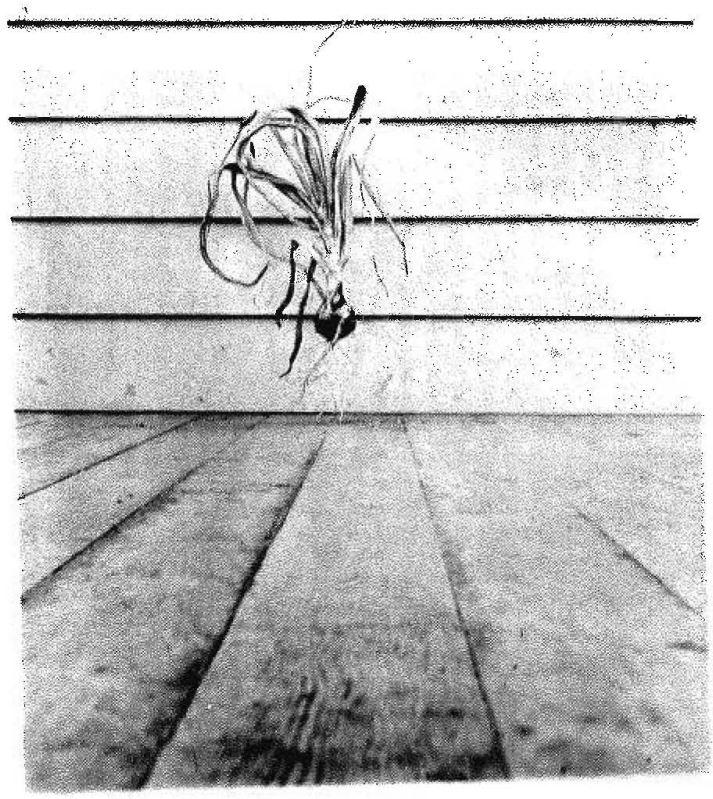


Plate VI.

Figure 10. Aeolothrips fasciatus 2d stage larva (×43½)

Figure 11. Limothrips tritici after Packard '72.

a. Supposed male (=larva of Aeolothrips)

b. Larva

c. Antenna of male (distal end)

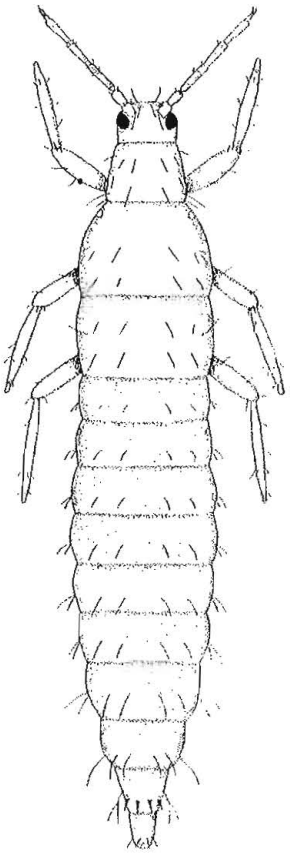
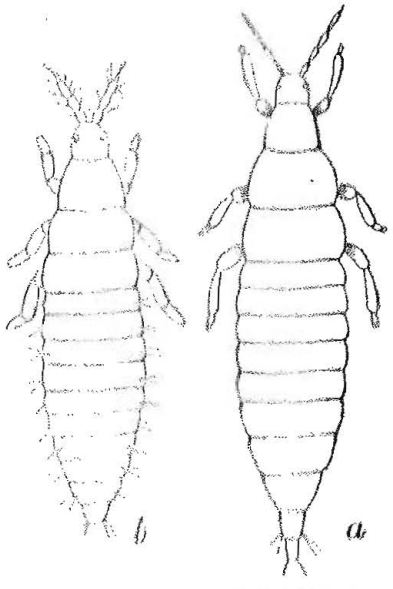


FIG. 2.



Larva and male of Limothrips tritici.

End of antennæ of male.

Plate VII.

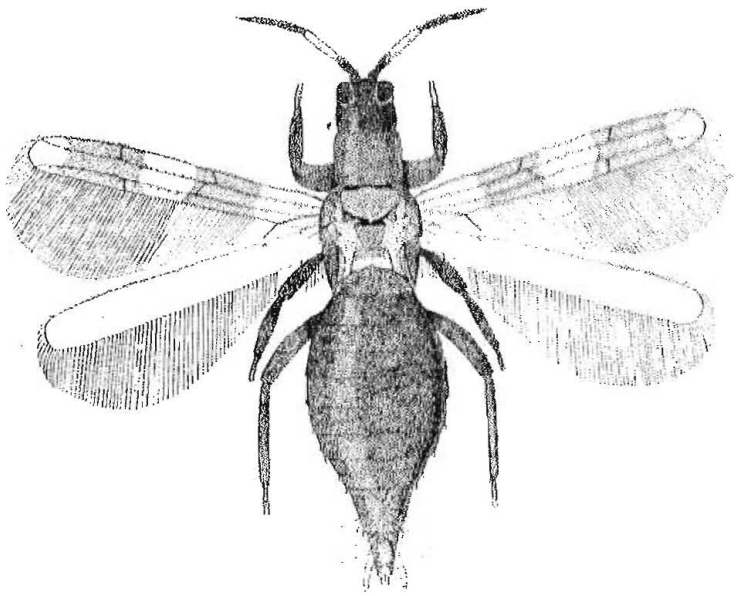
Aeolothrips fasciatus

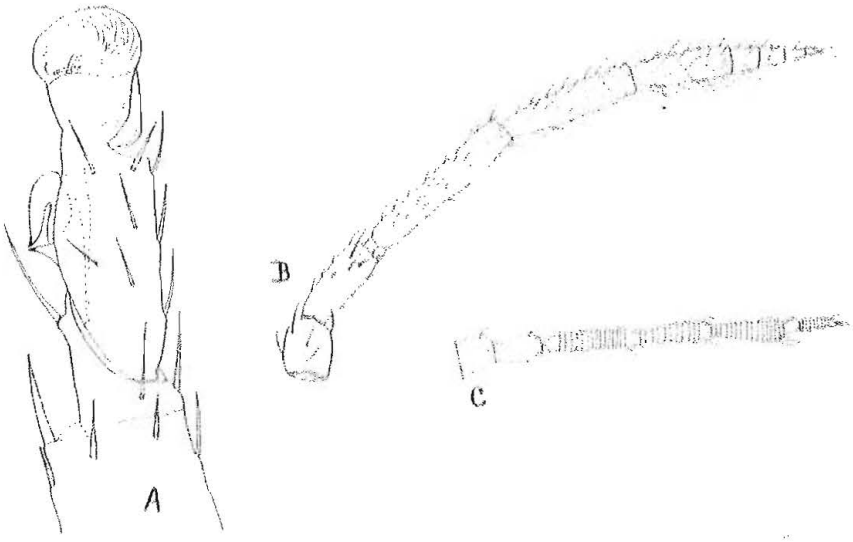
Figure 12. Adult female (×33½)

Figure 13. A. Fore tarsus of adult female (×317½)

B. Antenna of adult female (×133)

C. Antenna of second stage larva (×130)




A
B
C